THE UNIVERSITY OF ALBERTA

LOWER MIETTE ROCKS AT JASPER, ALBERTA

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF GEOLOGY

by

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April, 1962

ABSTRACT

This study has concentrated on the development of the basal part of the Lower Miette Formation in the Tekarra Creek map-area, Jasper. The rocks under investigation, assigned to the Windermere Group, were apparently deposited in a deltaic environment and consist of alternating argillaceous and arenaceous units. In the basal 820 feet the arenaceous units are nearly linear. Two mutually perpendicular trends of sand bodies can be distinguished, striking roughly northwest-southeast in the basal 450 feet, and approximately northeast-southwest in the overlying 370 feet. The basal sands have been interpreted as marginal barrier-island deposits delineating the palaeogeographic shoreline, and represent a destructional deltaic phase. The overlying sands are thought to consist of distributary channel deposits representing a constructional deltaic phase. The sediments appear to have come from an igneous and metamorphic source-area less than 50 miles to the northeast.

At Tekarra Creek the Lower Miette strata, severely deformed and metamorphosed during the Laramide orogeny, form a series of plunging folds and are cut by a thrust striking subparallel to the fold axes. On the basis of mineral assemblage the rocks have been assigned to the quartz-albite-muscovite-chlorite subfacies of the greenschist metamorphic facies.

Potassium-Argon ages of detrital muscovite from the Old Fort Point, Miette and Jasper Formations range from 1776 ± 90 to 1046 ± 50 my. The maximum age, obtained from the coarsest sample, supports the belief that the source area was underlain by rocks of the Churchill Province of the Canadian Shield, which are thought to range from 1600 to 1800 my. The degree of up-dating may be a function of grain-size.

ACKNOWLEDGEMENTS

The writer wishes to acknowledge the help and guidance received from the members of the Department of Geology, and in particular from Dr. H. A. K. Charlesworth in his capacity as thesis supervisor. The latter made this study possible, not only by his own work and interest in the geology of the Jasper area, but by initiating the relevant detailed studies carried out by D. B. Remington and M. R. Stauffer. The A.A.P.G. volume, "Recent Sediments, Northwest Gulf of Mexico", has served as an invaluable reference in the course of this work. Thanks is also due to Elfriede Grillmair for checking the space-trigonometric calculations of the fracture analysis, and to Wm. F. Johnston for voluntary drafting services.

The financial assistance received in the form of the Pan-American Petroleum Corporation Graduate Fellowship in Geology, a Teaching Assistantship of the University of Alberta, and field expenses underwritten by the Research Council of Alberta and Shell Oil Company of Canada, Limited is also gratefully acknowledged.

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INTRODUCTION

The rocks of the Miette Formation outcrop near the eastern edge of the Main Ranges of the Canadian Rocky Mountains at about latitude 53°, near the townsite of Jasper. Previous geological work in this region has been carried out by McEvoy (1898), Walcott (1913), Allan, Warren and Rutherford (1932), Charlesworth and Remington (1960), Remington (1960), Charlesworth, Evans and Stauffer (1961), Evans (1961a), and Stauffer (1961).

In the vicinity of Jasper the Pyramid thrust, which forms the eastern boundary of the Main Ranges, brings to the surface a thick sequence of Precambrian strata assigned to the Windermere Group, which are conformably overlain by the Lower Cambrian Cavell Formation. Charlesworth *et al*., (1961, p. 3) divided this sequence, in ascending order, as follows:

Jasper Formation - Unknown thickness - sandstones and conglomerates, with some argillites and algaloid carbonates near the top.

Miette Formation -

Upper - 2500 feet estimated - primarily argillites.

Lower - 2500 feet estimated - argillites, sandstones and pebble-conglomerates.

Old Fort Point Formation - 1200 feet - argillites and siltstones, with some limestones and limestone-breccias.

Unnamed Sandstone - Thickness unknown.

The strata, which now belong to the greenschist metamorphic facies, structurally form a series of anticlinoria and synclinoria (Figure 1) sub-parallel to the strike of the Pyramid thrust (Charlesworth et al., 1961, Plate I).

It is with the structure and stratigraphy of strata comprising the basal part of the Miette Formation that this thesis is concerned. Although these beds outcrop over a large area in the vicinity of Jasper, this study has concentrated on their development in the Tekarra Creek map-area, the location of which is shown in Figure 1. In order to obtain a fuller picture of the palaeogeography, however, some investigation of basal Miette beds away from the map-area was carried out.

In the Tekarra Creek map-area basal Miette beds overlie the Old Fort Point Formation previously mapped by Evans (1961a). Part of the Miette section is repeated by a thrust.

Topographically, the map-area is characterized by a northwesterly trending 300-foot ridge, underlain by resistant strata of the Lower Miette Formation. In the northwest, opposite the Alpine Cabins, this ridge is truncated abruptly by the Athabasca River, resulting in a steep north-facing escarpment.

Fig. I

LOCATION MAP

Miette formation

Old Fort Point formation

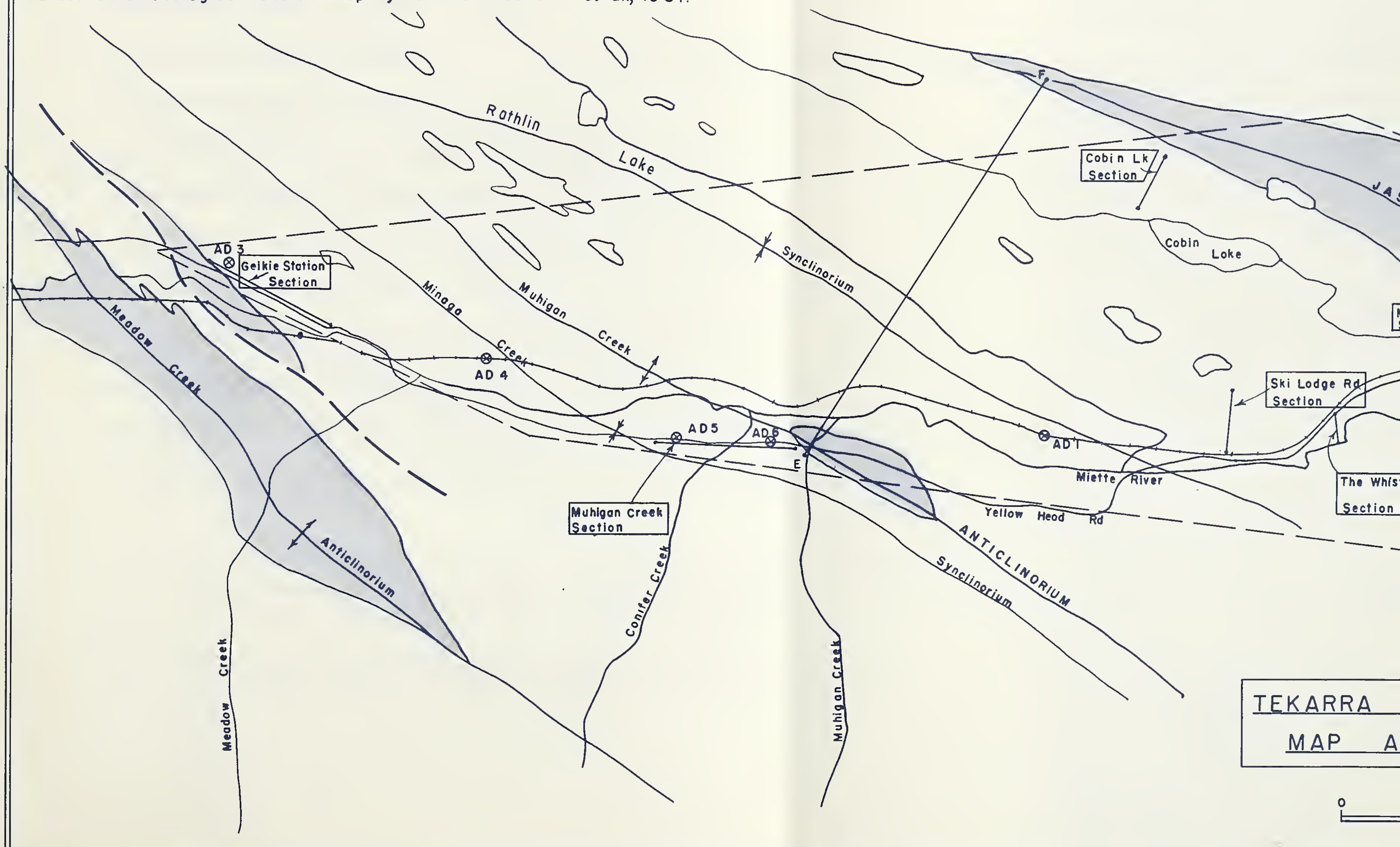
Approximate Area of Palinspastic Reconstruction

Based on a Geological Sketch-Map by H.A.K. Charlesworth et al., 1961.

LOCALITI

Tekorro Cre
Tekarro Cre
Signal Mtn
Miette Ave
Cobin Loke
Muhigan Cre
Geikle Statio
Ski-Lodge
The Whistle
Cross secti
Cross secti
⊗ Age Dat

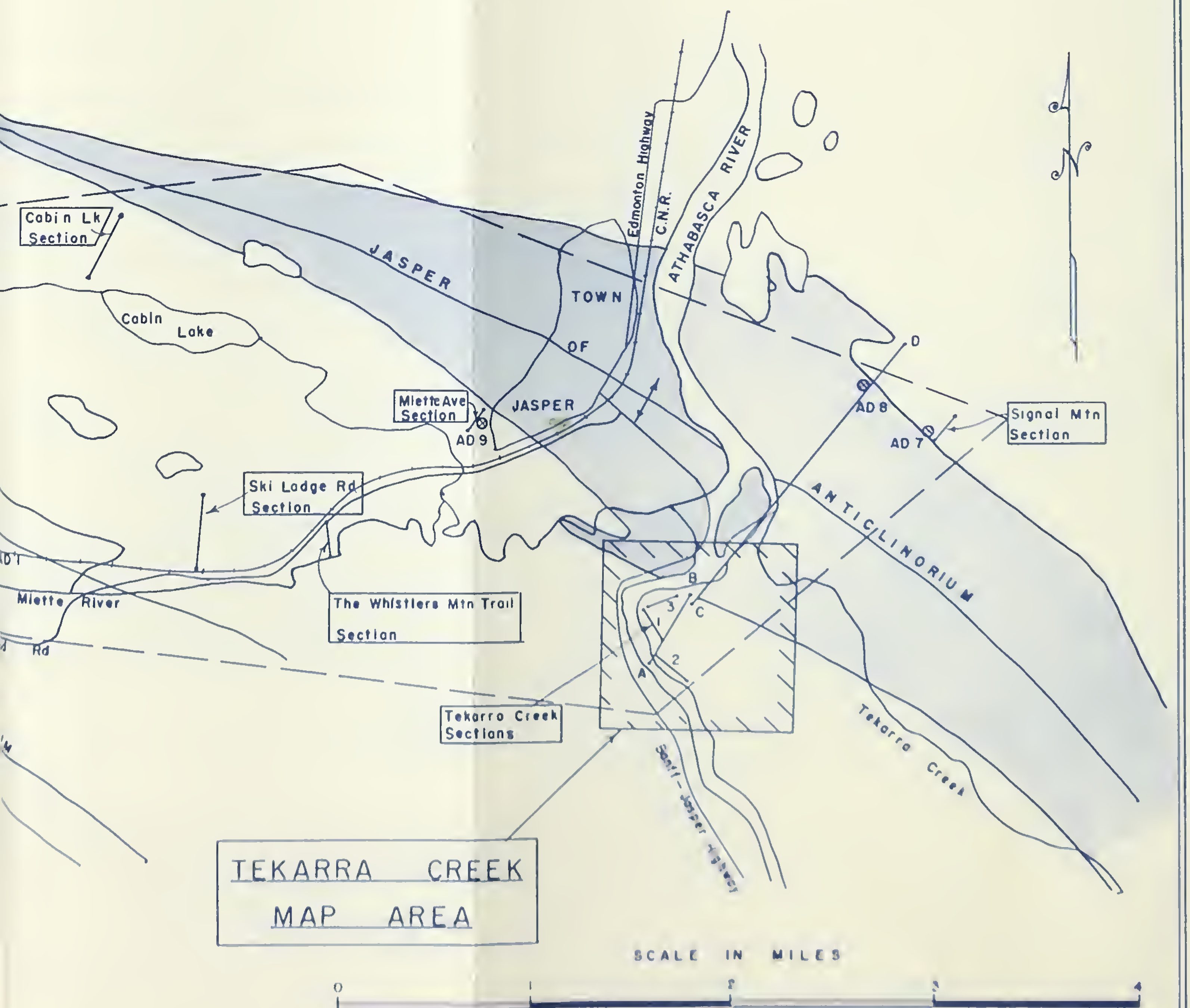
(AD 2 an



LOCALITIES SHOWN

Tekarra Creek Map Area
Tekarra Creek Sections 1, 2, 3.
Signal Mtn Section
Miette Ave Section
Cabin Lake Section
Muhigan Creek Section
Geikie Station Section
Ski-Lodge Road Section after Stauffer, 1961.
The Whistlers Mtn Trail Section after Remington, 1960.
Cross sections A to B, E to F.
Cross sections C to D based on Evans, 1961.
⊗ Age Dating specimen, AD1, 3, 4, 5, 6, 7, 8, 9.

(AD 2 and 10 are off this Map)



STRATIGRAPHY

Lithologic Units at Tekarra Creek

Introduction. The base of the Lower Miette Formation, which may be drawn at the lowest quartz-pebble-conglomerate overlying the Old Fort Point Formation (Evans, 1961a, p. 19) strikes diagonally across the map-area in a northwesterly direction (Figure 2). Some 1200 feet of Miette strata, divisible into ten mappable units designated numerically from 2 to 11 in ascending order, outcrop within the map-area (Figures 2, 3 and 4). The unit boundaries represent distinct lithologic breaks between alternating strata consisting dominantly of greenish-grey[1] argillite and silty argillite on the one hand, and greenish-grey, grey and brown[2] sandstone and conglomerate on the other. Following the usage introduced by Stauffer (1961, p. 5) these units are referred to as argillaceous and arenaceous units, respectively, and are very similar in character and lithology to those described by Remington (1960, pp. 5-18, 34-44) and Stauffer (1961, pp. 6-19). They are

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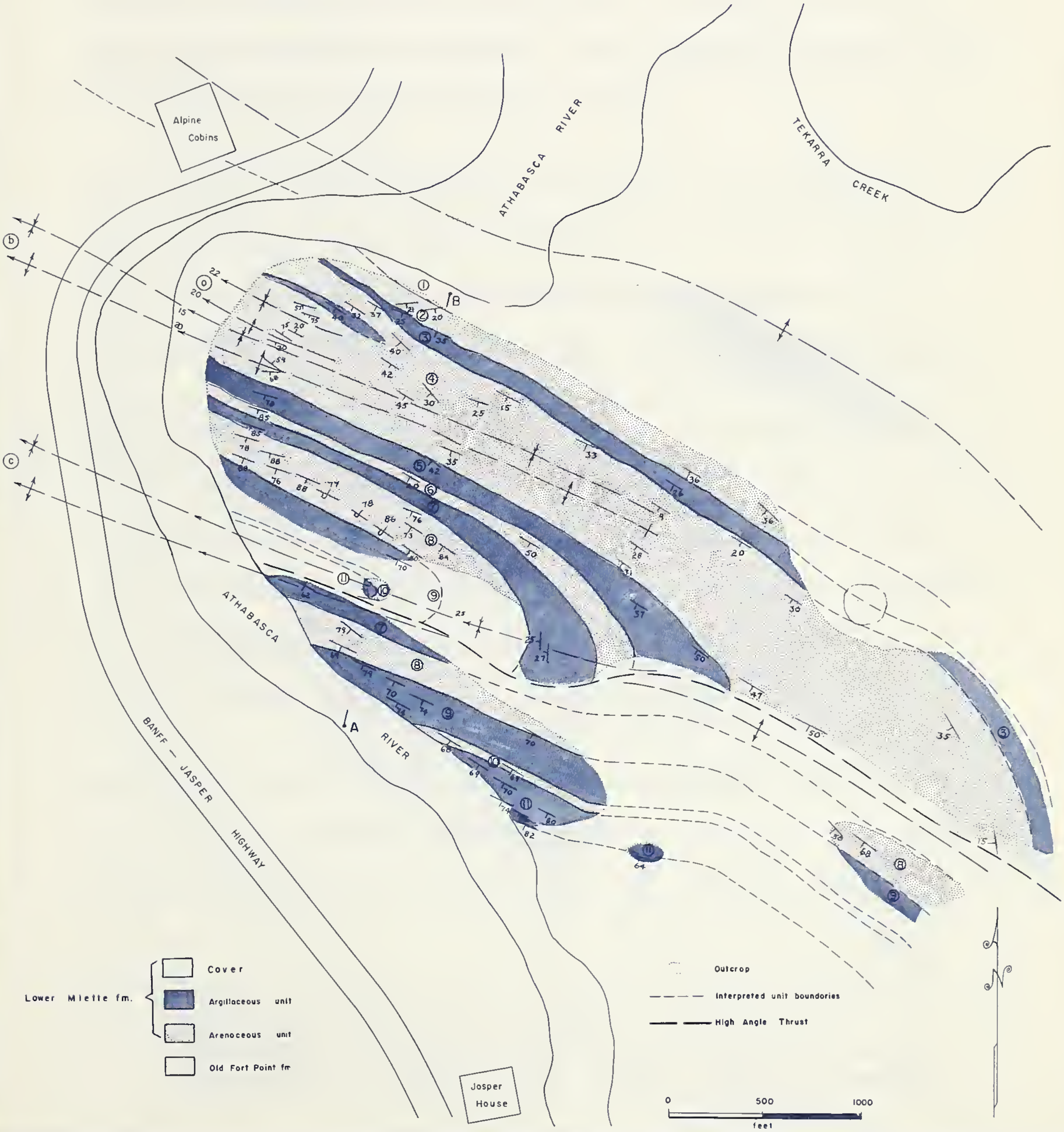
1 Range according to G.S.A. Color Chart: Grey Chroma 1, value 2-6, Hue N, 5YR, 5Y, 5GY, 5G - moist cut surface.

2 Range according to G.S.A. Color Chart: Grey Chroma 1, value 4-6, Hue N, 5YR, 5Y, 5GY, 5G - moist cut surface.

FIG 2

GEOLOGICAL MAP OF THE LOWER MIETTE FORMATION TEKARRA CREEK MAP-AREA



typically lenticular, with gradational or interfingering lateral contacts. Lateral thinning is sometimes coupled with a gradational decrease in conglomerate-size particles. The arenaceous units are rich in muscovite and chlorite, and ferruginous minerals, such as pyrite, siderite and limonite are common.

Unit 1 (25 feet plus) consists of sandy and silty argillite similar in appearance to the greenish-grey silty argillites of the upper part of the Old Fort Point Formation described by Evans (1961a, p. 18), and is therefore assigned to that formation.

Unit 2 (160 feet) is an arenaceous unit and represents the base of the Lower Miette Formation. It is generally poorly exposed in the map-area, except on the northwest escarpment. Ten per cent of the strata are green[3] arenites. The equivalent arenaceous sequence of the Signal Mountain section contains detrital mica flakes up to 20 mm across (see page 52).

Unit 3 (120 feet) consists of argillite and silty argillite. It thins rapidly northwest, which explains the absence of this unit from the Miette Avenue section (Figure 3). Seventy feet thick

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3 According to G.S.A. Color Chart:
Green Chroma 2, value 4, Hue 10G 4/2 - moist cut surface
Green Chroma 2, value 3, Hue 5G 3/2 - moist cut surface

on the top of the escarpment, it interfingers with conglomerate and sandstone lenses and measures 35 feet at the base of the escarpment, 200 feet to the northwest. On top of the escarpment this unit includes a conglomerate, laterally and vertically graded, which thickens from 0 to 5 feet within a distance of 30 feet in a southeasterly direction.

Unit 4 is a 350-foot arenaceous unit, which includes a lenticular silty argillite band with a maximum thickness of 35 feet on the top of the escarpment. Like Unit 3, the argillite thins to 10 feet in a northwesterly direction and gradually pinches out toward the southeast. "Granite" granules (Plate I) up to 3 mm in diameter, consisting of quartz and albite of composition An_6, have been identified, along with albite phenoclasts of composition An_5, which attain a maximum size of 8 mm. Eighteen per cent of the basal 120 feet and 5 per cent of the middle 130 feet of the unit consist of green arenites. The top 100 feet is essentially free of green arenites.

Unit 5 (110 feet) consists of poorly exposed argillite.

Unit 6 is a 50-foot arenaceous sequence, essentially free of green arenites.

LEGEND - PLATE I

A. Photomicrograph; portion of "granite" granule - unit 4 (see p.7) X 35.

B. Same as A - crossed nicols.

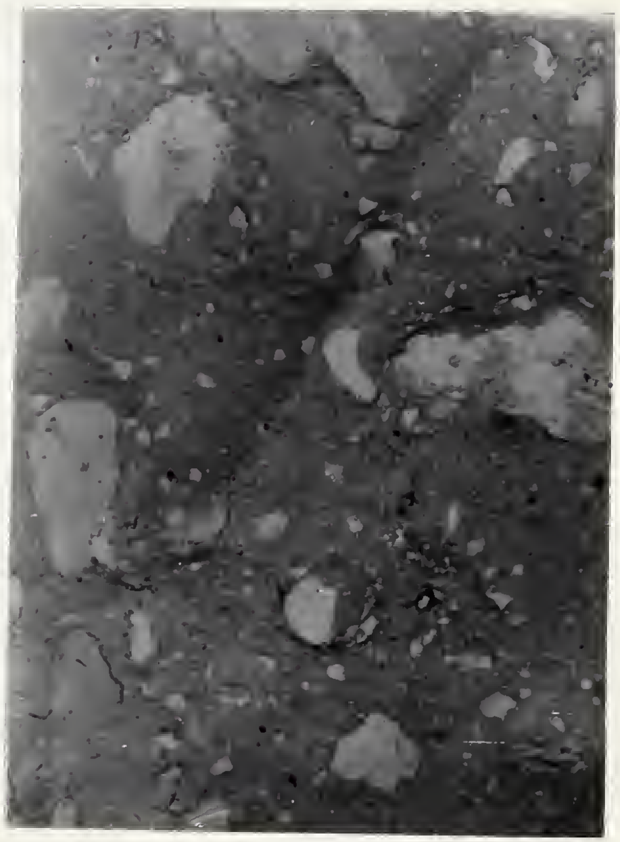
C. Photograph of thin section - 6-inch lithic paraconglomerate-band in argillaceous unit 7 (see p. 12).

D. Six-inch lithic paraconglomerate-band in argillaceous unit 7 (see p. 12).
The $1\frac{1}{2}$-inch square specimen is cut in the sub-parallel bedding and fracture-cleavage planes.

A

B

C



D

<u>Unit 7</u> (40 feet) consists mainly of silty argillite. It includes a 6-inch band of very thin-bedded and cleaved lithic paraconglomerate described on page 12 (see also Plate I).

<u>Unit 8</u> (100 feet) is a cliff-forming arenaceous sequence, essentially free of green arenites. In the northwest this unit is repeated on both sides of the thrust (Figure 2, Table I). The correlation is based on total thickness, lithology of the overlying and underlying strata, and lithologic character of the unit itself. Although small pyrite crystals and associated rusty stains are not uncommon in other arenaceous units, the distinct horizon of large pyrite crystals and nodules found in Sections 1 and 2 at approximately the same position further strengthens this correlation. No section was measured across Unit 8 outcropping in the southeast. However, the thickness and general lithology of this arenaceous unit is similar to the Unit 8 outcrops in the northwest. The horizon of large pyrite crystals is even more striking in this southeastern outcrop. Steep bedding planes of Unit 8 form cliffs up to 100 feet high in all three locations.

<u>Unit 9</u> (200 feet) is an argillaceous sequence which includes at the very top a one-foot bed of greyish-green argillite, interbedded evenly with dark grey and black $\frac{1}{4}$-inch laminae. A similar unit, possibly correlative with Unit 9, has been found in the Muhigan Creek section (Figure 3).

TABLE I

Correlation of Unit 8 Across Thrust

Section 1		Section 2	
	Covered interval		Argillite unit
6 ft.	Interbedded conglomerate, sandstone and argillite	9 ft.	Interbedded argillite, sandstone and conglomerate
5 ft.	Argillite	4 ft.	Argillite
62 ft.	Graded conglomerate containing pyrite horizon 20 ft. from top	68 ft.	Graded conglomerate containing pyrite horizon 25 ft. from top
13 ft.	Sandstone	18 ft.	Spotty outcrop, sandstone and conglomerate
15 ft.	Graded conglomerate	4 ft.	Conglomerate
	Argillite unit		Spotty argillite outcrop
101 ft.		103 ft.	

Unit 10 (30 feet) is an arenaceous sequence with no green arenites.

Unit 11 (70 feet plus) consists mainly of silty argillite, interbedded with some sandstone bands.

Sedimentary Structures

The most outstanding characteristic of the Lower Miette Formation at Tekarra Creek, as elsewhere, is the lenticular nature of the conglomerate and sandstone beds, coupled with graded bedding of the waning current type (Pettijohn, 1957, p. 171). In both the argillaceous and arenaceous units trough cross-stratification, loadcasting, indistinct flowcasted loadcasts, and vague ripple markings described by Remington (1960, pp. 5-18) and Stauffer (1961, pp. 6-13, 26-28) are common. The cross-stratification data obtained at Tekarra Creek are summarized in a rose diagram in Figure 12 (see also page 36). No sedimentary slump structures were observed. The only feature not previously described is represented in a 6-inch, thin-bedded, conglomeratic argillite band in Unit 7 (Plates I, II). Following Pettijohn (1957, p. 261) it should properly be termed a lithic paraconglomerate. The rock contains between 20 per cent and 30 per cent poorly sorted phenoclasts of vein quartz, shale fragments, quartzite and other metamorphic rocks (Plate II), with a fine silt- to clay-size matrix.

LEGEND - PLATE II

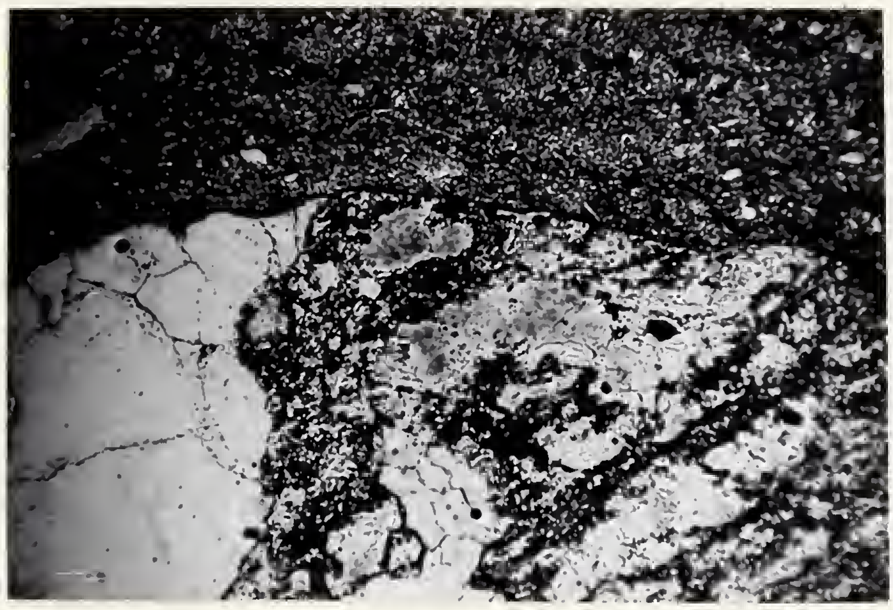
A. Portion of metamorphic rock fragment - lithic paraconglomerate of argillaceous unit 7 (see p. 12) X 35.

B. Same as A - crossed nicols.

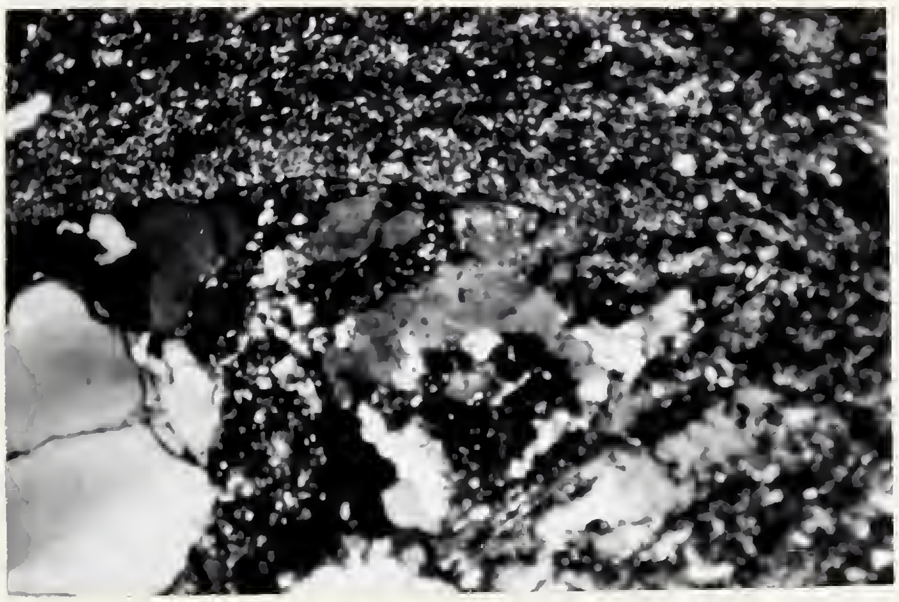
C. Portion of metamorphic rock fragment - lithic paraconglomerate of argillaceous unit 7 (see p. 12) X 35.

PLATE II

A



B



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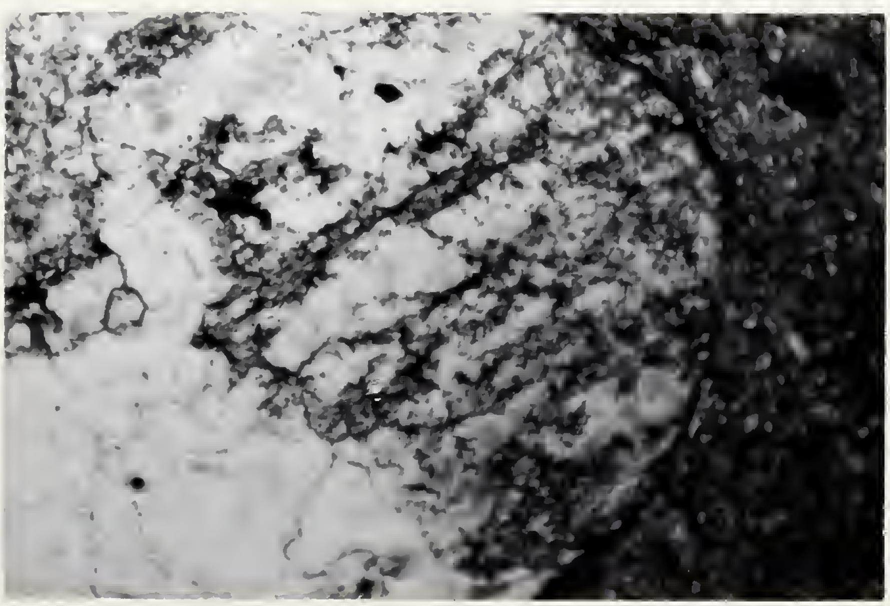

A paraconglomerate suggests turbid flow, and possibly an inclined surface of deposition (Pettijohn, 1957, p. 265). Numerous zones of argillaceous inclusions in the arenaceous units suggest reworking of fine-grained sediments (Stauffer, 1961, pp. 23, 32; Remington, 1960, p. 6). These shale and mudrock fragments range in length from less than ½ inch to several feet. Noteworthy occurrences of these shale fragments are indicated on Figure 4.

Palaeogeography

Introduction. In order to provide a sufficient number of control points suitable for facies mapping, five additional stratigraphic sections of basal Miette strata were measured at locations shown on Figure 1. All sections, except Cabin Lake which was paced, were measured with a 5-foot staff and begin at the top of the Old Fort Point Formation. These five sections, together with those measured at Tekarra Creek (pp. 6-12), Whistlers Mountain Trail (Remington, 1960), and Ski-Lodge Road (Stauffer, 1961), give a total of 15,000 feet of measured sections of Lower Miette rocks, and provide approximately one control point per square mile.

Signal Mountain Section (620 feet).

It is accessible by a $\frac{1}{2}$ mile trail, starting at the Old Fort Point bridge.

Miette Avenue Section (775 feet).

It is located at the western terminus of Miette Avenue, on the outskirts of the town of Jasper.

Cabin Lake Section (1860 feet).

It is accessible by a $2\frac{1}{2}$ mile trail branching off the Pyramid Lake Road. It was measured only on the basis of gross-lithology.

Muhigan Creek Section (1530 feet).

It was measured along the Yellowhead Road, westward from Muhigan Creek bridge.

Geikie Station (860 feet).

It was measured along the Yellowhead Road, eastward from the contact of the Old Fort Point Formation.

The Whistlers Mountain Trail Section (670 feet). (Remington, 1960, p. 34ff)[4].

The final correlation (Figure 3) and the isopach map of the

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4 In order to avoid possible confusion with the Arabic unit numerals used in the Tekarra Creek map-area, Remington's and Stauffer's unit designations have been converted into Roman numerals on Figures 3 and 4.

basal Lower Miette Formation (Figure 9) indicates that the Whistlers Mountain Trail section commences very close to the top of the Old Fort Point Formation, and for all practical purposes its basal arenaceous unit may be considered as the base of the Miette Formation. Remington reports 71 per cent greenish-grey and green arenites in the basal 450 feet and 47 per cent greenish-grey arenites in the upper 230 feet.

<u>The Ski-Lodge Road Section No. 1</u> (1320 feet). (Stauffer, 1961, p. 7)[4].

The relationship of this section to the base of the Miette Formation is shown on Figure 3. The seven sections measured by Stauffer (1961, Figure 4) within a distance of $\frac{1}{2}$ mile are considered here as one control point, although the stratigraphic trends exhibited by this east-west series of sections have been fully considered in this study.

<u>Tekarra Creek Section</u> (1220 ± 25 feet)

For details see pages 6-12 and Figure 3.

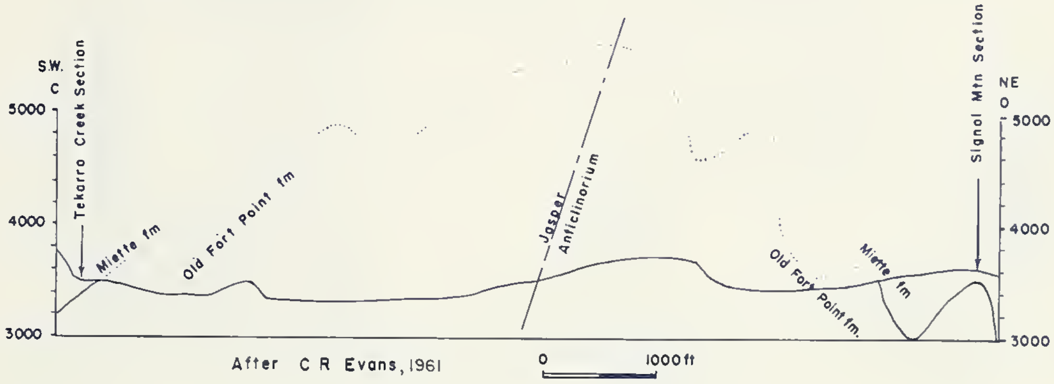
The stratigraphic columns of these eight sections (Figure 3) have been divided into arenaceous and argillaceous units, and zones of interbedded coarse and fine clastics. On the basis of argillaceous and arenaceous units alone any correlation between these sections is highly questionable, except in the case of the basal part of

the Miette Avenue and Cabin Lake sections (Figure 3). In order to use grain-size information for correlation purposes, and since it is impossible to obtain accurate grain-size data by mechanical analysis of these well-indurated rocks, some idea of the differences in grain-size of various units was gained by estimating the size of the largest grains in each bed (see Figure 4). Pettijohn (1957, p. 249) reports that "in many fluvial gravels the maximum size present is some function of the mean size present. Because of this relation it is possible to substitute the more easily determined largest size for the mean size in facies mapping".

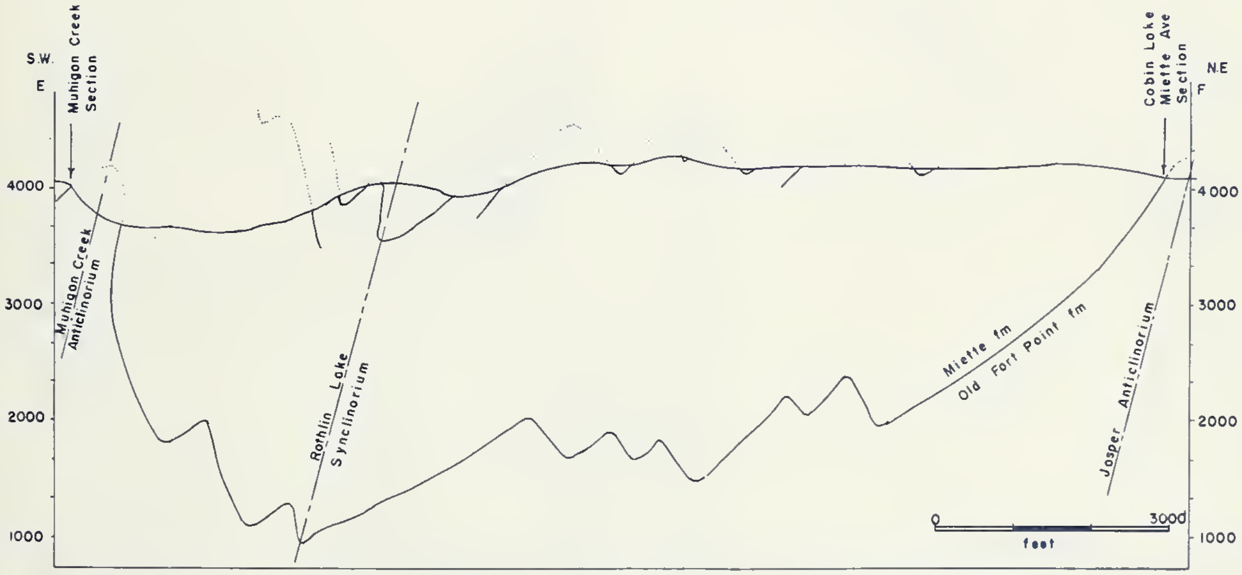
Construction of a Palinspastic Map. The structural map of the Jasper-Geikie area (Charlesworth *et al.*, 1961, Plate I) permits the construction of a palinspastic map (Figure 6) suitable for palaeogeographic reconstructions. With the aid of two structural cross-sections, CD and EF (Figures 1 and 5), two elongation-coefficients (defined here as the distance before folding divided by the present distance) of 1.22 (CD) and 1.55 (EF) were calculated. Griffiths (1962, in preparation) estimates an average shortening of 40 per cent in the Wynd Station map-area, which corresponds to an elongation-coefficient of 1.67. However, his short, local cross-sections include the most steeply dipping folds of the cross-

FIG. 5

STRUCTURAL CROSS-SECTIONS USED FOR PALINSPASTIC RECONSTRUCTION



After C R Evans, 1961



Based on a Geological Map published by H.A.K. Charlesworth et al., 1961.

PALINSPASTIC BASE MAP CONSTRUCTION

Spatial parameters are only approximate due to the uncertainties inherent in palinspastic reconstruction

Key Control distances are given in miles

———— Present distances

– – – – – Palinspastic elongation

Elongation Coefficient C.D. 1.22, E F 1.55 } Cross-sections Fig. 5
Average 1.385

Primarily based on a map of the Precambrian Geology of the Jasper – Geike area published by H.A.K. Charlesworth et al., 1961.

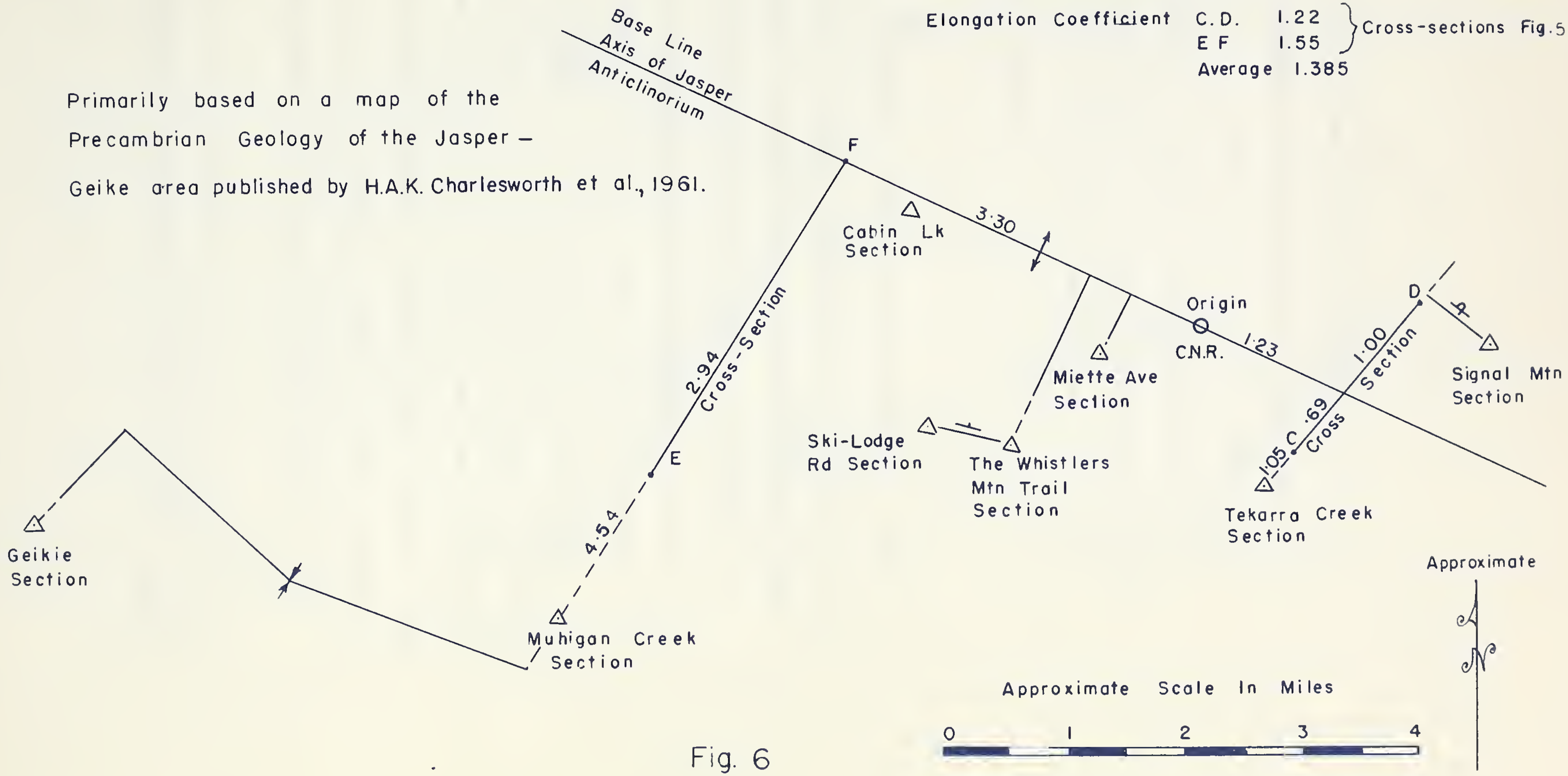


Fig. 6

section EF. Using an average elongation-coefficient of 1.4, and the axis of the Jasper anticlinorium as a base line, the palinspastic base map was constructed (Figure 6). The plunge and the swing in strike of the Jasper anticlinorium has been neglected in this construction. The spatial parameters on the palinspastic map, such as the north direction and scale, are therefore only approximate.

<u>Shoestring Sands</u>. Remington (1960, p. 22) and Stauffer (1961, p. 32) have postulated a deltaic environment of deposition for the Lower Miette Formation. In such an environment the major coarse deposits are distributary channels or shore-line sediments (Russell and Russell, 1939, pp. 163, 167) and as such are all linear. Shepard (1960, p. 197) held that it is to be expected that these linear deposits are preserved in the stratigraphic column of a subsiding area, particularly on the flanks of large deltas. The writer attempts to show that the sand and conglomerate bodies of the Lower Miette Formation are very nearly linear. They are therefore referred to as shoestring sands[5] and are designated, in ascending stratigraphic order, by the capital letters A to I.

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5 Average conglomerate percentage of arenaceous units: 39 per cent

For the following reasons, shoestring sand G has been identified in all sections (Figure 4) and for correlation purposes (Figure 3) has been used as a regional marker horizon.

(1) On the maximum grain-size logs (Figure 4) shoestring sand G is a distinctive arenaceous unit in all seven sections[6].

(2) It displays a combination of lateral grading and thinning, perpendicular to a northeast-southwest linear axis (Figures 7, 8).

(3) In Stauffer's seven sections (1961, p. 7), which were measured along an east-west line and reliably correlated by field relationships, shoestring sand G (equivalent to the basal parts of his unit IX) thins away from this linear axis.

(4) In five sections, four of which are in the axial region, the top 10 feet are markedly coarser grained than the immediately underlying strata (Figure 4).

(5) In all seven sections shoestring sand G is underlain by silt-size or shale-size sediments and overlain by a thick argillite or a covered interval (Figure 4).

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6 Information for a maximum grain-size log of the Cabin Lake section was not available. However, the correlation of Cabin Lake with Miette Avenue (Figure 3) enables one to trace shoestring sand G to this section.

FIG. 7

ISOPACH MAP —
Palinspastic Base

Contour interval 2 feet

Shoestring Sand G
Basal Lower Miette fm.
A Distributary Channel

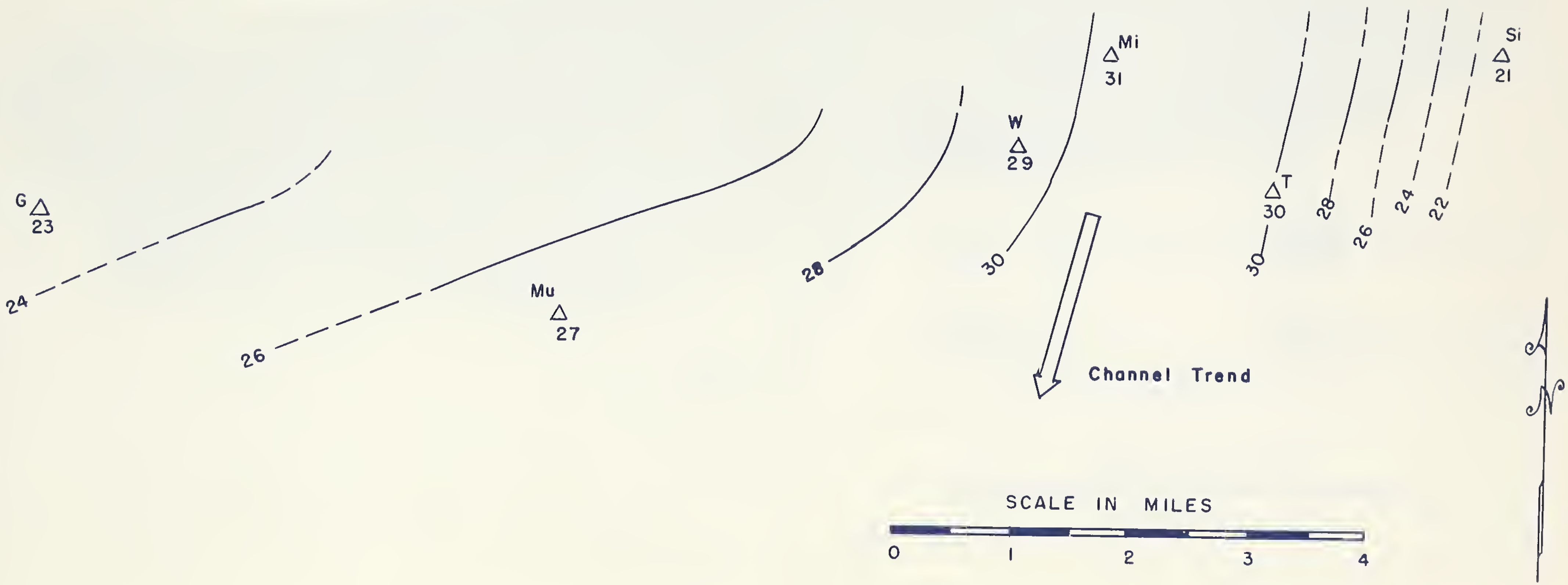
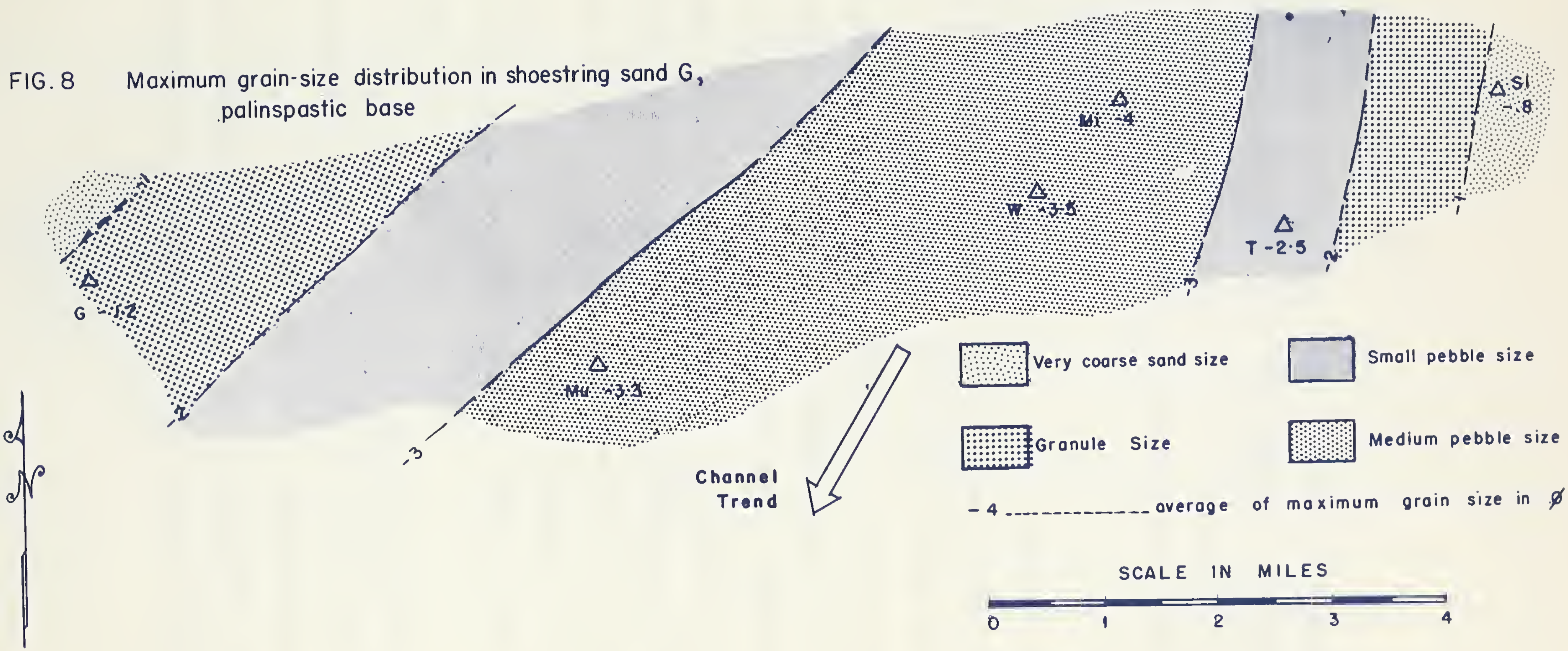


FIG. 8 Maximum grain-size distribution in shoestring sand G, palinspastic base



(6) An isopach map from the top of the Old Fort Point Formation to the top of shoestring sand G shows uniform thickening toward the southwest (Figure 9). This stratigraphic interval is henceforth referred to as the basal Lower Miette Formation.

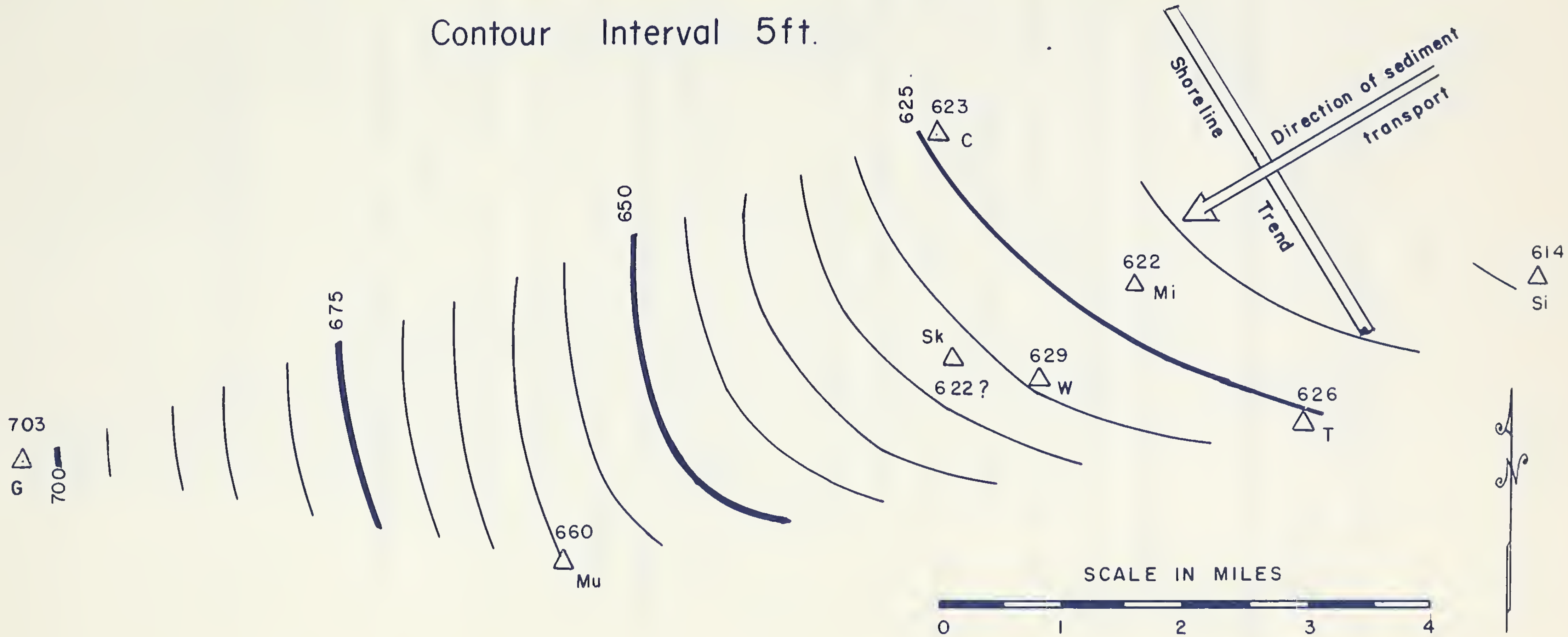
Considering conglomeratic material only, shoestring sand G, which apparently broadens southwest, has an average width of 12 miles. Its stratigraphic thickness is 30 to 60 feet along the axis, decreasing to 20 feet at the extremities of the area under investigation. A rapid decrease of maximum grain-size (16 mm to 11 mm over 5 miles) in the axial region toward the southwest indicates current flow from the northeast. This decrease is much less rapid than east-west changes in maximum grain-size (16 mm to 0.8 mm over 3 miles). The maximum grain-size indicates minimum transporting velocities of up to 100 cm/sec along the axis and down to 10 cm/sec at the margins (Hjulstrom, 1939, pp. 5-51; Visher, 1961, p. 292).

In the Cabin Lake section and Ski-Lodge Road sections 2 and 3 the arenaceous units, of which shoestring sand G forms the basal part, attain a thickness of 160 feet. Without detailed information on the amount and distribution of interbedded argillite and fine sandstone, it is suggested that at these two localities

FIG. 9

ISOPACH MAP BASAL LOWER MIETTE fm PALINSPASTIC BASE

Contour Interval 5ft.



shoestring sand G is overlain by a restricted north-south shoestring sand H. The margins of this sand may be represented in the Whistlers Mountain Trail and Miette Avenue sections (Figure 4) by conglomeratic interbeds.

In order to establish the identity of other shoestring sands, the vertical maximum grain-size distribution of the basal Lower Miette Formation was carefully examined in all control points (see Table II). Qualitative comparison of these distributions from one control point to another and consideration of all known pinch-outs suggest that shoestring sands A, B, C, D, E, F, H and I (Figures 10 and 11) are mappable units.

Lithologic and Textural Variation. Percentages of rock types and grain-size data for the Lower Miette Formation are summarized in Table III. Argillite, sandstone and conglomerate percentages were calculated for the entire Lower Miette Formation and for the basal part of the Formation. On the basis of maximum grain-size observations, a weighted average of maximum pebble-size was calculated for each section. The weighted average of maximum grain-size is defined as

$$\frac{s_1\ t_1 + s_2\ t_2 + s_3\ t_3\ \ldots\ldots}{t_1 + t_2 + t_3\ \ldots}$$

TABLE II

Classification of shoestring sands on the basis of maximum grain-size

(See Figures 3 and 4; Stauffer, 1961, Figure 4)

For abbreviations see Table III

Stratigraphic Interval and Shoestring Sands	Maximum grain-size						
	Conglomerate-size		Sand-size		Interbeds less than 1/3 of Interval (predominantly argillite)		Silt- or Clay-size
	More than 2/3 of interval	1/3 to 2/3 of interval	More than 2/3 of interval	1/3 to 2/3 of interval	Conglomerate-size	Sand-size	
I	T	Mi, Mu ?	G ?				
H	C, Sk					W	Mi, T, Mu
G	Mi, W, Sk	T, Mu		Si, G			
F	Si, T (G ?)			Mu			Mi, C, W, Sk
E	Si, T	W		Sk		G	Mi, C, Mu
D	T, Sk	W	Mu		G		Si, Mi, C
C	Mi, W, C	T	Mu		Sk, G		Si
B	Mi, Sk, C	Si	Mu			G	T, W
A	T, Mi, C	Si, W, Sk			G	Mu ?	

FIG. 10

FACIES MAP – Shoestring Sand A
A marginal barrier island
Basal Lower Miette fm Palinspastic Base

(20, 30, 50 ------- % Congl, % SS, % Arg)

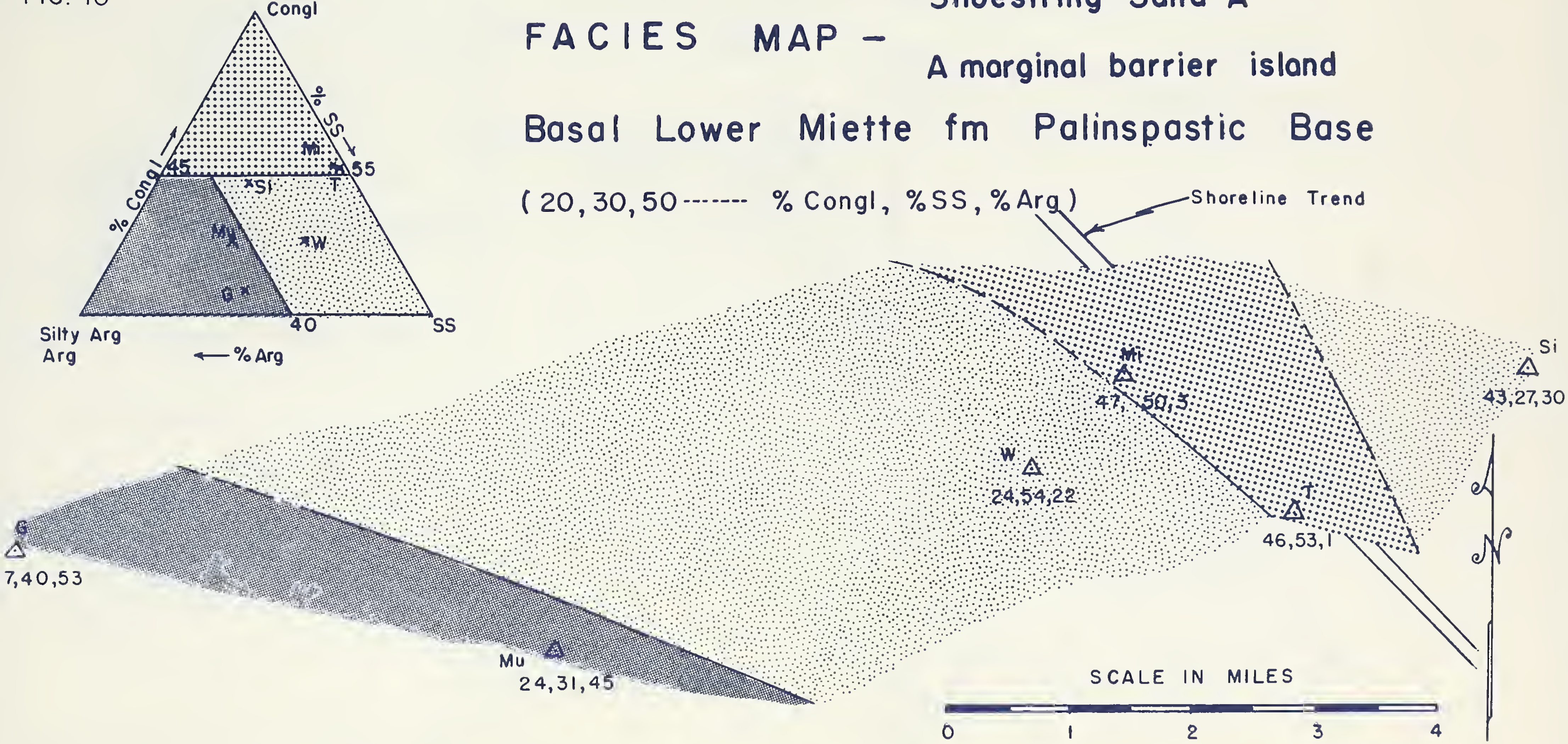


Fig. 11 Trend of Shoestring Sands A, B, C, D, E, F, G and I.

Palinspastic Base

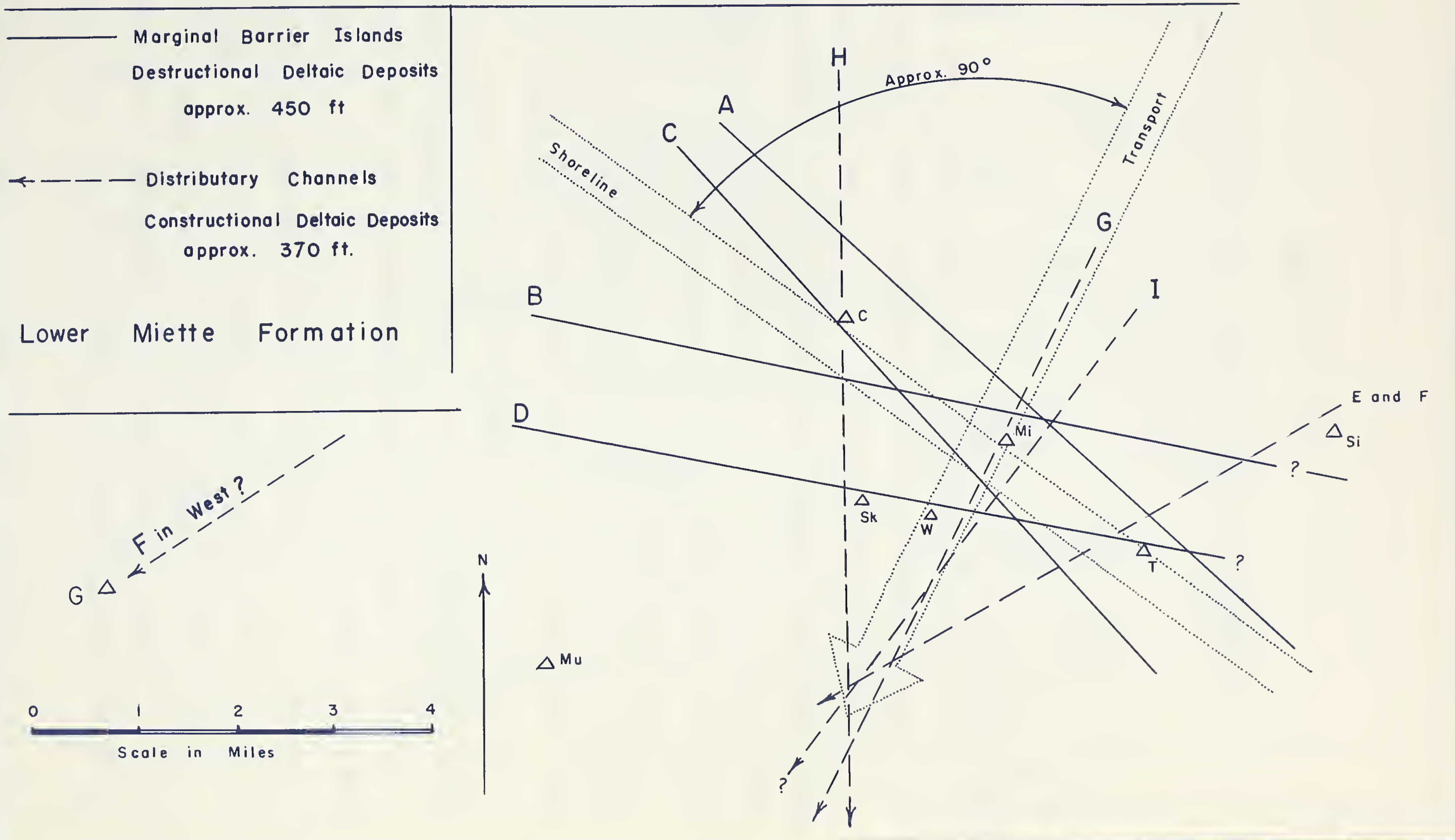


TABLE III

Percentages of Rock Types, Lithologic Units, and Grain-size Data for Eight Sections of the Lower Miette Formation, Jasper Area, Alberta.

Lower Miette Formation

Abbreviation	Section	Total Footage	% Conglomerate	% Sandstone	% Argillite including cover	% Cover	% Arenaceous Units	% Argillaceous Units	Approx. max. particle size (mm)	Weighted average of max. pebble size (mm)
Si	Signal Mtn.	622	26.6	22.8	50.6	35	49.4	50.6	30	14.85
C	Cabin Lake	1856	-	-	34.5	high	65.5	34.5	cobble size	-
Mi	Miette Ave.	775	26.1	26.0	47.9	19.0	52.1	47.9	30	11.45
T	Tekarra Cr.	1220	23.7	34.8	41.5	10.5	58.5	41.5	50	12.14
W	Whistlers Mtn. Tr.	620	18.4	40.3	41.3	9.4	58.7	41.3	15	7.90
Sk	Ski-Lodge Rd. No. 1	1320	-	-	38.0	unknown	62.0	38.0	30	-
Mu	Muhigan Cr.	1528*	16.6	35.7	47.7	20.4	52.3	47.7	25	7.87
G	Geikie Stn.	862	11.8	38.6	49.6	6.0	50.4	49.6	20	8.40
	Basal Lower Miette Formation									
Si	Signal Mtn.	614	27.0	22.8	50.2	35.2	49.8	50.2	30	14.85
C	Cabin Lake	623	29.7*	30.0*	40.3	average	59.7	40.3	cobble size	-
Mi	Miette Ave.	622	30.4	30.8	38.3	21.2	61.2	38.3	30	11.30
T	Tekarra Cr.	626	35.8	42.5	21.7	zero	78.3	21.7	50	13.80
W	Whistlers Mtn. Tr.	629	19.6	38.9	41.5	10.0	58.5	41.5	15	7.90
Sk	Ski-Lodge Rd. No. 1	622*	18.5*	46.3*	35.2	-	64.8	35.2	30	-
Mu	Muhigan Cr.	666	15.8	40.4	43.8	23.0	56.2	43.8	25	7.46
G	Geikie Stn.	703	14.5	42.0	43.5	7.6	56.5	43.5	20	8.40

* approximate

where s_1 is maximum grain-size in interval 1 and t_1 the thickness of interval 1 (Snedecor, 1956, p. 17).

The results indicate a definite decrease of conglomerate percentage westward, with the exception of Signal Mountain. However, the average weighted conglomerate size is largest in Signal Mountain. Tekarra Creek shows a percentage decrease of arenaceous units up-section, whereas Muhigan Creek and Cabin Lake show an increase. The percentage of conglomerate decreases up-section in both Tekarra Creek and Muhigan Creek. In Tekarra Creek the percentage of argillite increases up-section, whereas in Cabin Lake and Muhigan Creek it decreases.

Constructional and Destructional Deltaic Phases. Two sets of shoestring sands, approximately perpendicular to one another, are recognizable. The basal sands A, B, C and D trend northwest-southeast, while E, F, G, H and I average to a northeast-southwest direction. This latter direction approximately coincides with the direction of transport postulated by Stauffer (1961, pp. 14, 32) and Evans (1961a, p. 19) for the Miette and Old Fort Point Formations respectively.

"Marine deltas are seaward-thickening embankments of sediments deposited during the constructional phase and modified by the

destructional phase" (Scruton, 1960, p. 82). "The constructional phase consists of the classical top-set, fore-set and bottom-set beds" (ibid., p. 97). The linear shoestring sands in the top-set beds represent distributary channels. "A destructional phase of delta building is characteristic of large marine deltas. It immediately follows the constructional phase and may begin even before construction is entirely completed. The destructional phase is a period of compaction and modification of rapidly extending front lines" (ibid., p. 100). In the destructional phase winnowing of fine sediment and concentration of coarse material into thin veneers, linear beach ridges and linear barrier islands, takes place (ibid., p. 82). The trend of beach ridges and barrier islands is roughly perpendicular to that of distributary channels (Shepard, 1960, p. 81). "Large alluvial plains at river mouths are built up in a step by step manner. Local delta construction is followed by partial destruction and later by another constructional phase. A large alluvial plain consists of several imbricating deltas, each lying partly on the toes of earlier deltas and partly on the surface that existed prior to any delta building. The stratigraphic components of younger deltas become seaward extensions of their older counterparts. When the beds are buried beneath still younger ones, their

full history can be understood only by recognizing their deltaic origin and by knowing how deltas are built" (Scruton, 1960, p. 82).

In order to determine whether the two channel directions discussed on page 32 can be related to the constructional and destructional deltaic phases, percentage matrix (less than 75 microns) estimates were made on 31 thin sections, taken mainly from the Tekarra Creek succession. Conglomeratic sandstones of shoestring sands A, B, C and D contain an average of 21 per cent matrix, and all horizons above it an average of 37 per cent matrix. This suggests that the basal part has been wave-sorted and winnowed and therefore represents destructional deltaic facies (see Shepard, 1960, pp. 208, 209).

Heavy mineral studies of the Lower Miette Formation (Griffiths, 1962, in preparation, tabulates Remington's, 1960, and Stauffer's, 1961, results as well as his own) indicate better sorting in shoestring sands A, B, C and D. In the following table of heavy mineral ratios, rutile (S.G. 4.24) and zircon (S.G. 4.6-4.7) have been slightly concentrated, as compared with tourmaline (S.G. 3.0 - 3.3) in the basal 450 feet (compare "selective sorting by specific gravity", Pettijohn, 1957, pp. 561-565; "hydraulic factor", Folk, 1959, p. 95).

LOWER MIETTE FORMATION	RUTILE: TOURMALINE	ZIRCON: TOURMALINE	NO. OF SAMPLES
450 - 1300 feet	.03	3.4	7
0 - 450 feet	.12	3.7	8

If shoestring sands A, B, C and D represent slightly wave-sorted barrier island deposits, and if shoestring sand G represents an essentially horizontal distributary channel, then the isopach interval (Figure 9) from the base of sand A to the top of G should give a gradient slightly more than the seaward slope of recent barrier islands (compare Scruton, 1960, p. 102, Figure 17). A gradient of 10 to 13.5 ft/mile, scaled off from the isopach map, compares favourably with Shepard (1960, p. 105, Figure 9). He shows 17 profiles characterizing the seaward slope of various shorelines characterized by barrier islands and other types of shorelines of the United States. In scaling off these profiles, an average slope of 67 ft/mile is obtained for steep, cliffed shores, and an average of 14 ft/mile for the Gulf Coast barrier islands.

In marginal deltaic environments (Van Andel and Curray, 1960, p. 348) barrier island deposits, together with other shoreline facies, are characterized by a greenish colour, due to glauconite (Shepard, 1960, p. 121; Rusnak, 1960, p. 195, Figure 30;

Van Andel and Curray, 1960, p. 348). Although the greenish colour of the basal arenaceous units (see pages 6-12 and 17) is due not to glauconite but to chlorite, it is possible that chlorite may be the stable Precambrian counterpart of glauconite (compare Pettijohn, 1957, pp. 456, 467). Alternatively glauconite, a potassium-bearing iron silicate, may not be stable in the greenschist metamorphic facies, altering to chlorite, the potassium going into sericite and muscovite. The chlorite may also represent an alteration product of detrital biotite.

On the basis of the present data, it is not possible to say whether shoestring sands A, B, C and D represent one or more destructional deltaic phases. Nevertheless, the basal sands appear to represent the destructional facies (Figure 10), and the upper sands the topset, constructional facies (Figures 7, 8). The facies map of the basal Lower Miette Formation shows the destructional phase to be predominant, and the constructional phase to be secondary (Figure 12).

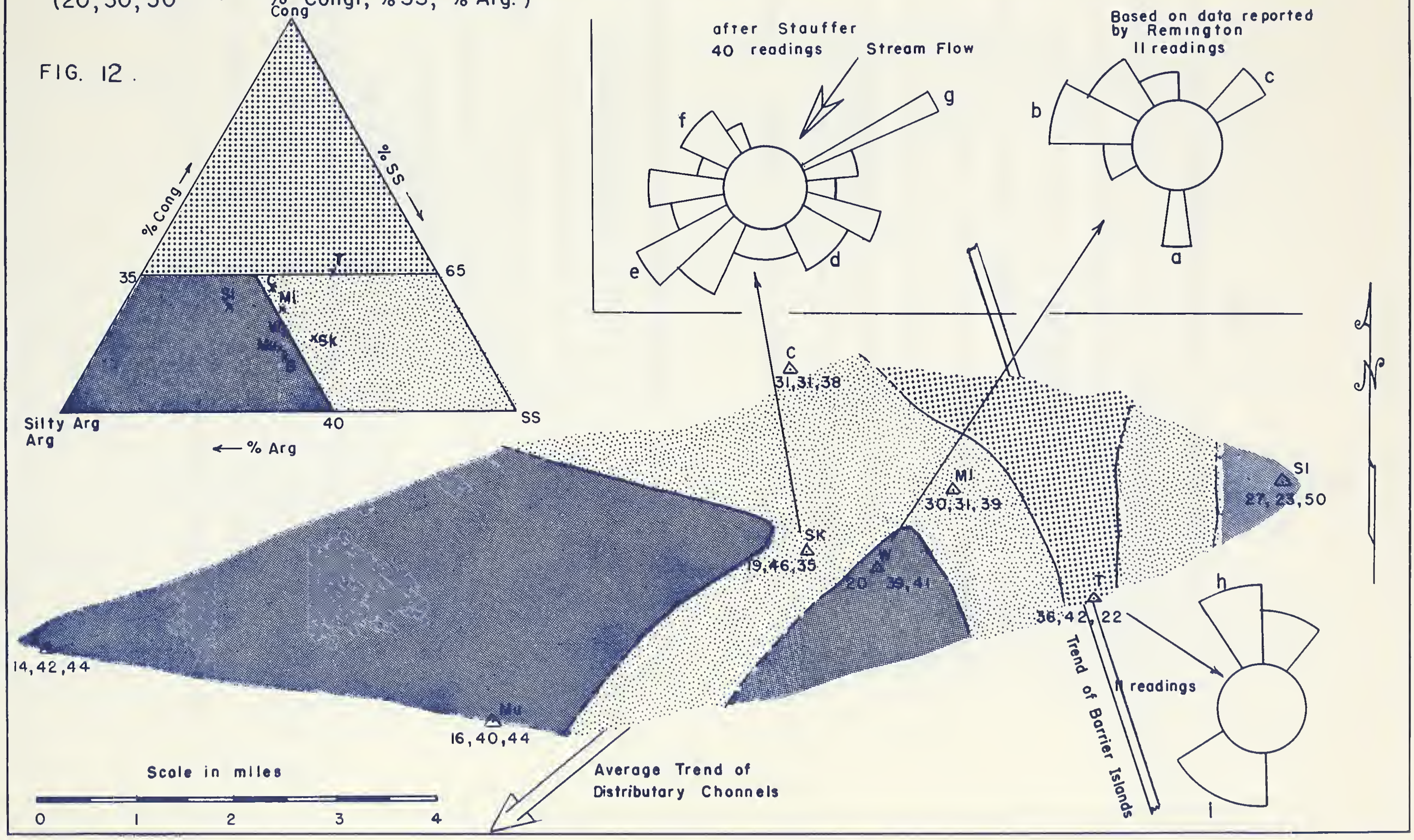
The cross-stratification rose-diagrams (Figure 12), based on some 60 readings only, and in general agreement with this interpretation, show poorly defined maxima sub-parallel to the constructional and destructional trends, and a fairly good minimum direction in the case of Stauffer's data (1961, Figure 8). The

BASAL LOWER MIETTE fm.

Facies Map on a Palinspastic Base & Rose Diagrams of Cross – Stratification

(20, 30, 50 .... % Congl, % SS, % Arg.)

FIG. 12.



very limited stratigraphic control of single readings at Tekarra Creek does indicate that both the constructional and destructional components are present throughout the entire stratigraphic interval, though one may be predominant over the other. The directions labelled b, f, d and h may represent littoral currents, sub-parallel to the barrier island trend. Directions e and i are components representative of the topset constructional phase; components g and c may be interpreted as a direction to be expected in inlets and tidal channels (Tanner, 1954, pp. 2471-83; compare Muraour, 1953, pp. 1099-2101).

Shoreline and Source Area Projection. At the beginning of Miette time the average shoreline-trend (Figures 10, 11, 12), as delineated by the barrier island deposits (Van Andel and Curray, 1960, p. 363; compare Tanner, 1954, pp. 886-889), is given by shoestring sand A striking roughly northwest or north-northwest in the vicinity of Jasper.

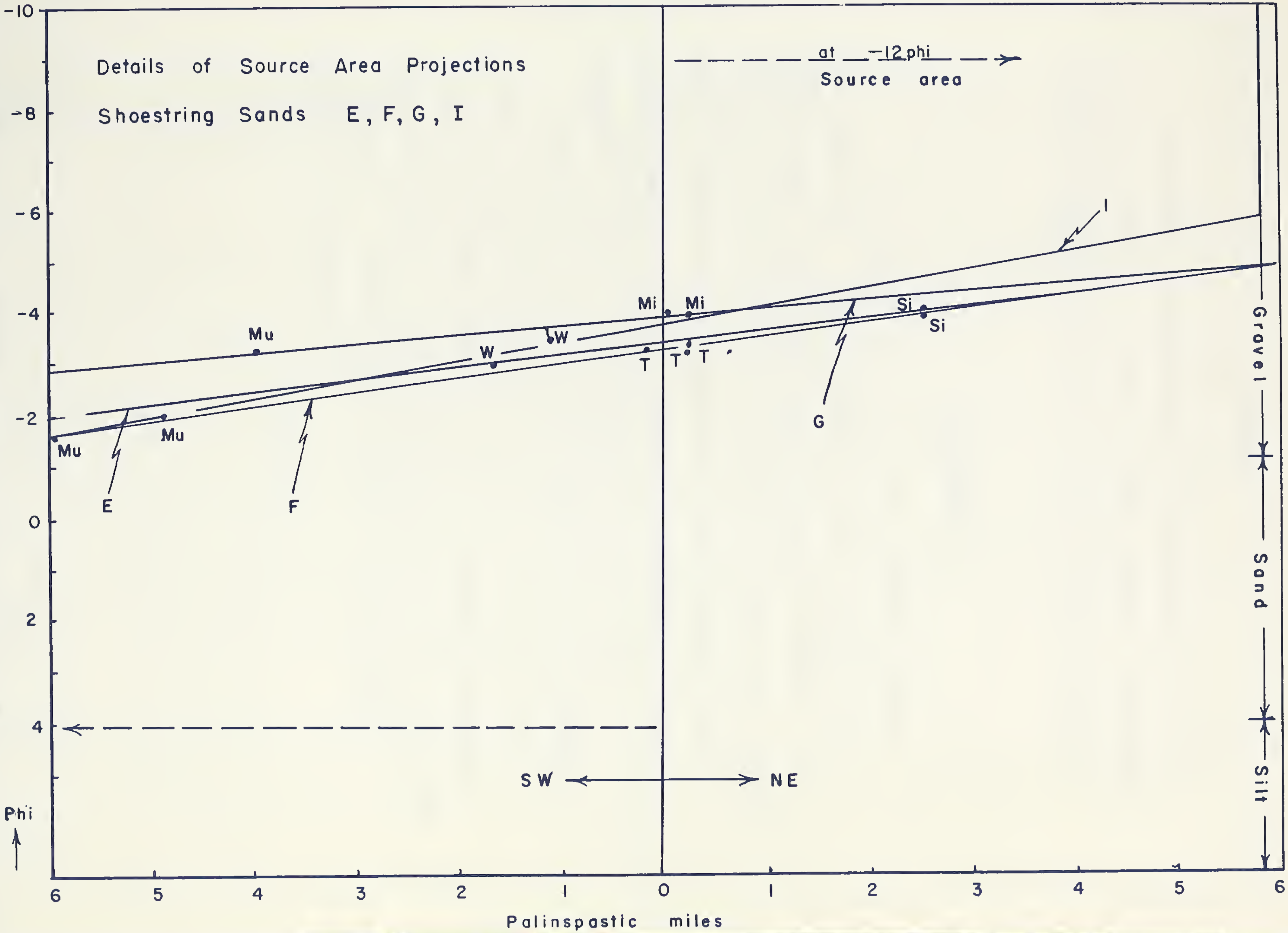
The best documented distributary channel is shoestring sand G and the maximum grain-size of the axial control points can be used for a source area projection (Figure 8). As implied by Pettijohn (1957, p. 529, Figure 122) the logarithms of the maximum grain-size plotted against distance measured along the

channel direction very nearly fall on a straight line (Figure 13). When this function is extrapolated to a maximum grain-size of 4 metre (-12 phi), it suggests that the source area was in the neighborhood of 50 palinspastic miles to the northeast.

Conclusions. The basal 450 feet of the Lower Miette Formation at Tekarra Creek seems to consist predominantly of destructional deltaic deposits. The overlying 370 feet represent mainly constructional deltaic sediments. These conclusions facilitate facies classification of the arenaceous and argillaceous units at Tekarra Creek according to Van Andel and Curray (1960, p. 348).

Basal Lower Miette Formation	Predominant Marginal Deltaic Facies
Basal 450 feet	
Arenaceous units	Barrier and destructional delta facies
Argillaceous units	Bay and inlet facies
Top 370 feet plus	
Arenaceous units	Constructional delta top-set facies, consisting of point-bar channel deposits, natural levee, crevasse and delta front platform
Argillaceous units	Interdistributary bay and "marsh" deposits.

FIG. 13


Details of Source Area Projections
Shoestring Sands E, F, G, I
at -12 phi
Source area
Gravel
Sand
Silt
Mu
Mu
Mu
W
W
Mi
Mi
T
T
T
Si
Si
E
F
G
I
SW
NE
Phi
-10
-8
-6
-4
-2
0
2
4
6
5
4
3
2
1
0
1
2
3
4
5
6
Palinspastic miles

In general, an environment of imbricating deltas, under subsiding conditions and periodic lateral change of delta fronts, prevailed during the deposition of the Lower Miette sediments.

Provenance

The mineralogy of the coarse, detrital particles (see pages 6-12) suggests a primary source terrain of acid plutonic rocks, metamorphic rocks and possibly pegmatites. The source area projection (page 39) indicates a close source, approximately 50 miles toward the northeast, which generally agrees with the coarse and angular nature of the detritus (see also Remington, 1960, pp. 20-22; Stauffer, 1961, pp. 30-32).

Remington's (1960, p. 22) suggestion that the Churchill Province of the Canadian Shield represents the source area (compare also Burwash, 1958, p. 217) is supported by Potassium-Argon age dating of coarse, detrital muscovite from the very basal conglomerate. A maximum age of 1776 my $\pm$ 90 was obtained (pages 56-58 and Table V).

STRUCTURE - TEKARRA CREEK MAP-AREA

Folding and Faulting. The structural field data are presented in Figures 2 and 14. Three pairs of folds, designated "a", "b" and "c" are shown, which in trend are sub-parallel to the northernmost anticline mapped by Evans (1961a, p. 28) within the Old Fort Point Formation. The two southernmost pairs, "b" and "c", are probably a continuation of the folds mapped by Remington (1960, p. 4) in the Whistlers Mountain Trail map-area (see Map of the Precambrian Geology of the Jasper-Geikie Area by Charlesworth *et al.*, 1961, Plate I). All folds like the adjacent part of the Jasper anticlinorium plunge northwest.

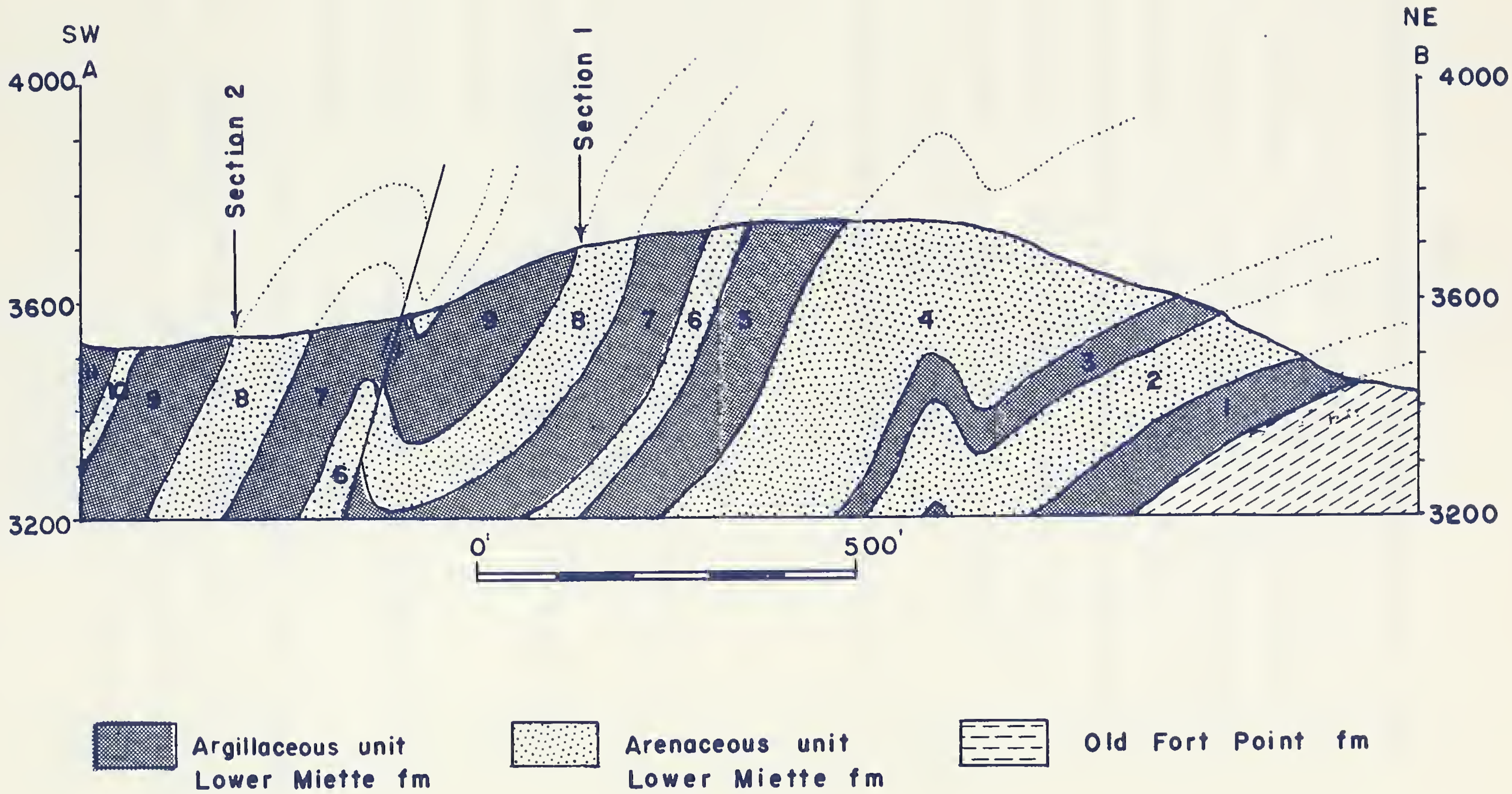
The fold pair "a" is well exposed on the basal Lower Miette escarpment visible from the Alpine Cabins. Both the syncline and the anticline plunge 22° to 20° northwest and flatten out in approximately 600 feet in a southeasterly direction.

The fold pair "b", and especially the syncline, is clearly visible on the above-mentioned escarpment from the Banff-Jasper Highway. Both folds plunge 15° to 20° northwest and die out within half a mile toward the southeast.

The syncline of the fold pair "c" is readily apparent in the outcrop pattern (Figure 2) since it involves interbedded, alternating lithologies and extends over the whole map-area. It

FIG.14

STRUCTURAL CROSS-SECTION AB, TEKARRA CREEK



plunges 25° northwest in the centre of the map-area, but there are indications of a changing plunge toward the southeast. Its axial plane dips steeply southwest. Only two dip readings suggest the existence of the anticline in the west; however, it has been assumed to continue toward the southeast. It is suggested that the common, partly overturned limb of these two folds was replaced by a steeply dipping thrust at a later stage of deformation. Its dip and strike is sub-parallel to the orientation of the axial plane of the folds.

The following evidence argues for the existence of the fault:

1. Repetition of strata, as shown in Table I.
2. Existence of blocky, 6-inch quartz-vein fragments in the cover north of the anticlinal axis "c".
3. Abrupt termination of reasonably continuous major units along strike.

A structural cross-section, A to B, as indicated on the Location Map (Figure 1) is shown in Figure 14.

It can be noted that the structural trends of the Jasper-Geikie area, as mapped by Charlesworth _et_ _al_., (1961, Plate I) swing toward the south in the eastern sector, which includes the Tekarra Creek map-area. As shown by a comparison of the cross-

sections CD and EF, less shortening was accomplished by folding in the general vicinity of the Tekarra Creek map-area than farther west (page 18). It is possible that in the east the thick competent sequence comprising the basal shoestring sands A, B, C and D (page 27), which are elongated sub-parallel to the structural trend (Figure 10), prevented the development of more steeply dipping folds. Additional shortening was then accomplished by thrusting, as suggested above.

The one-foot black shale horizon at the very top of Unit 9 yielded curved structures (Plate III) which are vaguely reminiscent of trilobitic forms. However, they are probably of mechanical origin, since they are invariably associated with pronounced slickensiding. The symmetrical, semi-circular traces are nearly perpendicular to the slickensiding, and may be a manifestation of tension associated with bedding plane slip.

LEGEND - PLATE III

Hand Specimen Photographs

A & B. Curved structures - top of argillaceous unit 9 (see p. 45).

PLATE III

A

B

Fracture Analysis. The poles of 130 fracture readings, obtained in the field from southwest dipping beds only (Figures 15/15, 15/16) are presented on contour diagrams (Figure 15). The concentrations thus obtained were statistically analyzed using Fisher's method (Fisher, 1953, pp. 295-305).

This vector addition method permits the calculation of a mean orientation and a radius of confidence; the latter may be looked upon as a measure of the scatter of the averaged individual readings.

Seven significant concentrations in their present field orientation and their orientation after rotation of the bedding plane into the horizontal (Table IV) were divided into shear and extension fractures on the basis of their appearance. Approximate relative age relationships were established on the basis of displacements observed in the field.

TABLE IV

FRACTURE ANALYSIS

Set (Figure 15)	Present mean orientation			Type		Orientation with bedding horizontal			
	Strike	Dip	Radius of Confidence*			Strike	Dip	Radius of Confidence*	
A - S	N. 27 E	87 SE	12.7°	Extension	Regional	N. 25 E	86 NW	7.8°	Early
E - Q	N.127 E	62 NE	7.0°	Shear	Regional	N.127 E	76 SW	9.6°	
F - T	N.174 E	78 E	7.5°	Shear	Tekarra Creek	N. 89 E	22 SW	7.8°	Inter-mediate
B - P	N. 93 E	32 N	6.9°	Shear	Tekarra Creek	N.106 E	83 SW	3.9°	
C - O	N. 20 E	30 NW	11.1°	Shear	Tekarra Creek	N. 78 E	76 NW	7.6°	Late
D - Q	N.152 E	22 NE	7.1°	Shear	Tekarra Creek	N.127 E	84 SW	6.3°	
A'- S'	N. 24 E	86 SE	3.8°	Extension	Tekarra Creek	N. 22 E	89 NW	6.5°	

* 95% probability

POTASSIUM-ARGON AGE DETERMINATIONS OF DETRITAL MUSCOVITE

Introduction

Evans (1961a, pp. 78-81), using the K/A whole-rock method on three Old Fort Point argillites, obtained ages of 346, 333 and 286 my. Evans (1961b, pp. 13-20) also suggested an unspecified reciprocal relationship between K/A age and orientation index (see Silverman and Bates, 1960, pp. 60-68 and page 51) of micas in the plane of the cleavage, as shown below.

Old Fort Point Formation, Member C

(after Evans)

SAMPLE NO.	ORIENTATION INDEX	K/A AGE (± 15 my)
AK 182	0.035	346 my
AK 187	0.050	333 my
AK 184	0.712	286 my

Stauffer (1962, personal communication), in an attempt to determine the geological age of the source area of the Miette Formation, obtained an age of 1330 ± 150 million years from detrital zircons, using the lead-alpha method[7].

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7 The age determination was made by the United States Geological Survey, Geochemistry and Petrology Branch.

This study deals with K/A age determination of detrital muscovite still oriented in the bedding plane.

Petrographic Descriptions of Samples

Introduction. Three samples were selected for K/A age determinations, in which detrital mica flakes greater than 0.15 mm were clearly oriented in the bedding plane. A fourth determination was made on a smaller size grade (0.15 to 0.10 mm) of one of the samples (Table V). The following petrographic data are based on optical and X-ray studies of oriented sections and muscovite separates. In general, detrital mica flakes in these well-indurated rocks are accommodated among other detrital grains (see Stauffer, 1961, Plate 4/A).

Sample AD8, from Member D, Old Fort Point Formation, Signal Mountain, is an olive-grey medium-grained sandstone consisting of quartz, plagioclase, mica and 40 per cent matrix. The muscovite, septechlorite (possibly all altered biotite) and biotite, up to 1 mm across, oriented in the bedding plane, is assumed to be detrital. The septechlorite and muscovite, less than 0.1 mm in diameter, oriented in the cleavage plane, is presumably of metamorphic origin. The muscovite sample AK 365, 0.5 to 0.15 mm, was separated from this specimen. It contained up to 5 per cent quartz and septechlorite contamination.

Sample AD7, from the basal arenaceous unit of the Lower Miette Formation, Signal Mountain, is a grey pebble-conglomerate consisting of metamorphic and vein-quartz; albite and micas; and 12.5 per cent matrix. The muscovite up to 20 mm across, and septechlorite in the bedding plane, is assumed to be detrital. The septechlorite and muscovite oriented in the cleavage plane (the majority does not exceed 0.1 mm) is presumably of metamorphic origin. Two muscovite samples were separated from this specimen: Muscovite separate AK 363, 4.0 to 0.7 mm, contained more than 98 per cent muscovite and less than 2 per cent septechlorite; Muscovite separate AK 364, 0.15 to 0.1 mm, contained more than 98 per cent muscovite, less than 2 per cent septechlorite and quartz.

Sample AD10, from the basal Jasper Formation (Charlesworth et al., 1961, Plate I), 1/3 mile west of Pyramid thrust along the Edmonton-Jasper Highway, is a very well-indurated, fine pebble-conglomerate to conglomeratic coarse-grained sandstone of igneous, vein and metamorphic quartz; microcline and micas; and 15 per cent matrix. On a cut surface it is very light grey, with brown staining of conglomerate-size interbeds. Individual laminae are well sorted. The muscovite up to 3 mm across is assumed to be detrital. Some septechlorite is present. The cleavage direction is not

immediately apparent. Muscovite separate AK 362, 0.5 to 0.3 mm, contained more than 98 per cent muscovite and less than 2 per cent quartz.

Petrofabric Analysis by Means of the X-ray Diffractometer.

In order to study preferred crystallographic orientation in rocks, two techniques have been developed. The X-ray beam may be transmitted through thin sections of a sample, or it may be diffracted from a smooth surface. The transmission technique (Silverman and Bates, 1960, pp. 60-68) provides adequate data for the peripheral portions of a pole diagram, but the central areas are blind spots. The reverse is true of the reflection technique (Schulz, 1949, pp. 1030-1033). In both techniques, geometric and absorption correction-factors have to be considered (Decker, Asp and Harker, 1943, pp. 388-392). In general, more than one sample has to be used in order to obtain a complete petrofabrics diagram. Jetter and Borie (1953, pp. 532-535) used a spherical specimen, which eliminated the correction factors, and a complete diagram could be obtained from a single sample. This technique has been used by Higgs, Friedman and Gebhart (1960, pp. 275-292) in comparing petrofabrics diagrams obtained by X-ray diffraction and by optical means from quartzite, marble and limestone.

In employing the reflection technique to the basal reflection (00,10) (00,16) of 10Å micas, it was possible to construct a partial petrofabrics diagram (Figure 16; compare Higgs, Friedman and Gebhart, 1960) of a very fine sand- to silt-size lamina (2 mm) of the Jasper Formation sample (AD10). It is questionable whether this lamina is representative of the total coarse sample. In addition, orientation indices for the bedding and "cleavage" micas were calculated. The orientation index, as defined by Silverman and Bates (1960, pp. 60-68) is a relative measure of the degree of orientation of micas in a given plane, and increases with increasing degree of orientation. It does not depend on the amount of mica oriented in that plane.

Orientation of 10Å Micas of Sample AD10

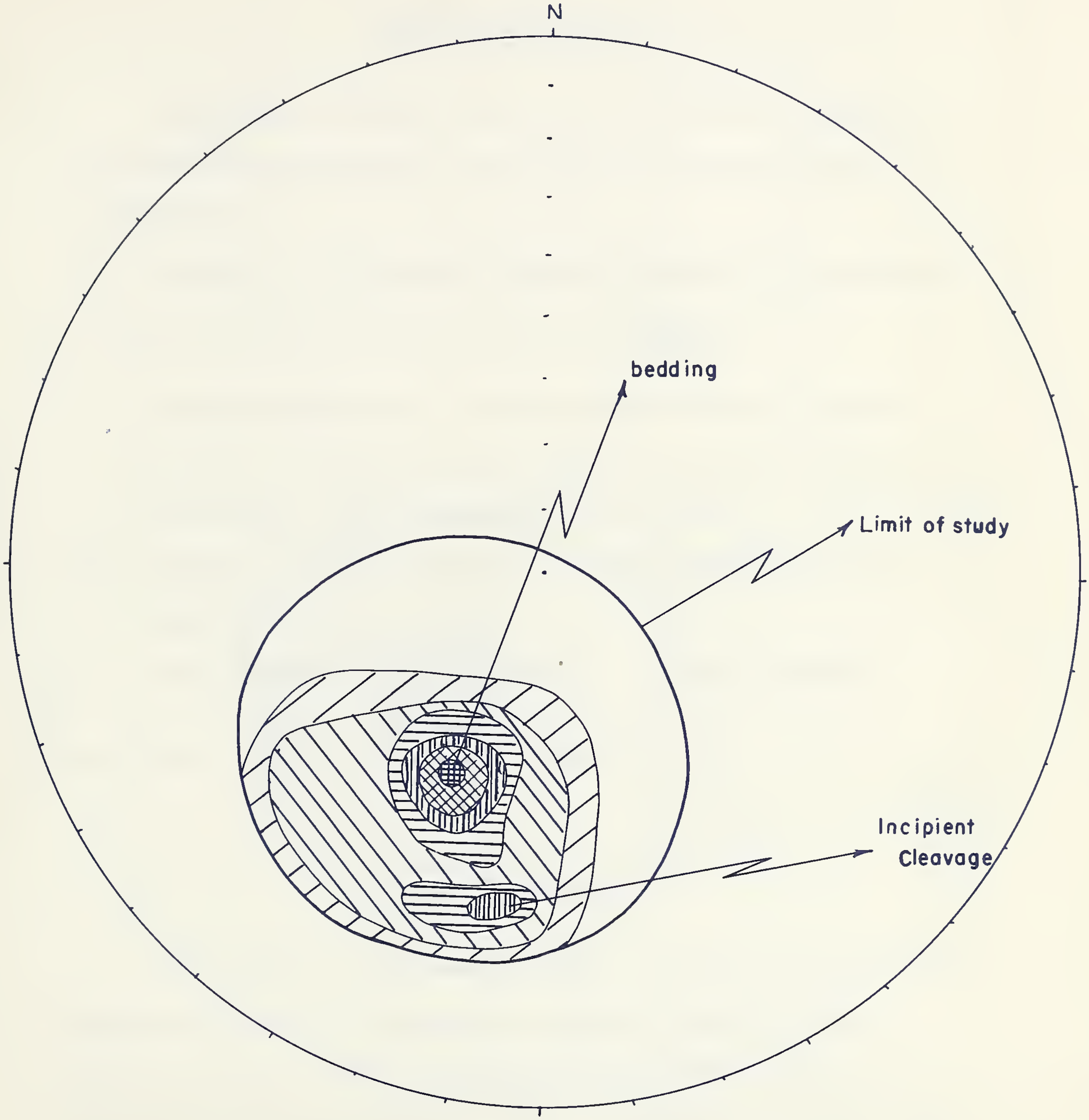
	PER CENT	ORIENTATION INDEX
In bedding plane	86 $\pm$ 22	0.0088
In "cleavage" plane	14 $\pm$ 3.5	0.1350

The "cleavage" micas are 17 times better oriented than the bedding micas.

FIG. 16

Petrofabrics Diagram

Schmidt Net



Contour diagram of poles to bosal mica planes on the basis of x-ray orientation study

sample A.D. 10 basal Jasper formation

Sample Preparation

Rock samples weighing from 15 to 25 lbs. were crushed and sieved and mica concentrates were separated from the suitable size fractions.

Separates of 98 per cent muscovite and better were produced by employing the following concentration techniques:

(1) Primary concentration: differential settling velocities in water. Sand-size, bent mica flakes settle out much slower than other non-platy detrital grains.

(2) Clean-up: Electrostatically charged polythene cover on a vibration board.

(3) Final separation of contaminants: magnetic separation.

The coarse separate AK 363 was hand-picked.

Age Determinations

Potassium-Argon age determinations were made on the muscovite separates (Table V). The coarsest muscovite separate AK 363 yielded a K/A age of 1776 ± 90 million years, which confirms a postulate by Remington (1960, p. 22), who suggested that the coarse clastics of the Miette Formation have been derived from the Precambrian Churchill Province of the Canadian Shield.

TABLE V

K/A Age Determinations of Detrital Muscovite

Location of Sample (Figure 1)	Muscovite Separate No.	Lithology	Stratigraphic Position	Grain-size of muscovite separate (mesh)	Median Diameter phi_m of separate	K/A Age Million Years	Distance from Pyramid thrust
AD 10	AK 362	Fine pebble conglomerate	Basal Jasper Formation	- 25 + 50	1.13	1046 ± 50	1/3 mile
AD 7	AK 363	Pebble conglomerate	Basal Lower Miette Formation	- 5 + 25	-0.75	1776 ± 90	over 2 miles
	AK 364	Same sample as AK 363		-100 + 140	3.00	1288 ± 65	over 2 miles
AD 8	AK 365	Medium sandstone	Member D, Old Fort Point Formation	- 35 + 100	1.88	1680 ± 85	over 2 miles

AK 363, AK 364 and AK 365 are stratigraphically within 50 feet of one another, while Evans' samples AK 182, 184, 187 are up to 400 feet lower down in the section (for details of Evans' samples see Evans, 1961b). AK 362 is estimated to be several thousand feet above the other samples.

The K/A age of 1046 ± 50 million years (AK 362) of the Jasper Formation can perhaps be understood in terms of a younger or mixed source, as indicated by the change in the mineralogy of the detritus, and as compared to the Miette Formation (see page 52). An alternative explanation could be increasing dynamo-metamorphism due to the closer proximity of the sample-location to the Pyramid thrust (Table V).

The muscovite separates AK 363, AK 364, AK 365, which are stratigraphically only 50 feet apart, indicate a direct relationship between increasing median diameter[8] and increasing age.

K/A Age of Detrital Muscovite and Metamorphism

The purpose of the following discussion is to show that there is strong evidence indicating that Evans' Palaeozoic ages (page 50) are related to the writer's Precambrian detrital ages (Table V) and that the maximum age obtained from the coarsest muscovite fraction is probably a maximum as well as a minimum source age. If the cube of the median diameter in phi of the

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8 Phi values increase with decreasing particle size (Krumbein, 1934, pp. 65-77; Folk, 1959, pp. 24, 44). Since log-normal size-distribution is assumed within the limited size-classes listed in Table V, the median can be calculated by arithmetically averaging the limits of a given size-class expressed in phi units.

detrital micas is plotted against K/A age, a seemingly straight line function is indicated for Evans' (page 47) and the writer's Old Fort Point and Miette age determinations (Figure 17). If this function is valid, it perhaps represents increasing radiogenic argon loss with decreasing particle size during metamorphism. Although the cube of the diameter indicates a volume function, the rapid increase of the ratio of surface area over volume, with decreasing diameter, may also have to be considered.

In order to test the validity of this function, comparable K/A muscovite ages published by Hart (1961, p. 192 ff) and Hower (1961, pp. 137-141) were plotted on the same basis (Figure 17)[9]. These plots suggest a logarithmic relationship in the finer size-fractions or a break in the slope (compare Evernden et al., 1961, pp. 78-99). Other, possibly comparable data regarding sanidine and biotite show no simple systematic relationship between grain-size and K/A age[10] and the validity of the dependence of K/A age on particle size during metamorphism can therefore not be conclusively demonstrated on the basis of the data presented here.

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9 Data by Burwash and Baadsgaard (1962, in press) is also included, although strictly speaking at least one of their separates (AK 189) does not represent detrital mucsovite. AK 126 and AK 194 are from Locality 5 at Thekulthili Lake; AK 189 is from Locality 1 at Salkeld Lake.

10 Smith, (1960, p. 131); Baadsgaard, Lipson, Folinsbee, (1960, pp. 147-157).

<u>Legend - Figure 17</u>

Function 1 ...... Evans-Steiner, Miette-Old Fort Point Formation - Lower horizontal scale

Function 2 ...... Hart, Clarendon, Vermont - Lower horizontal scale

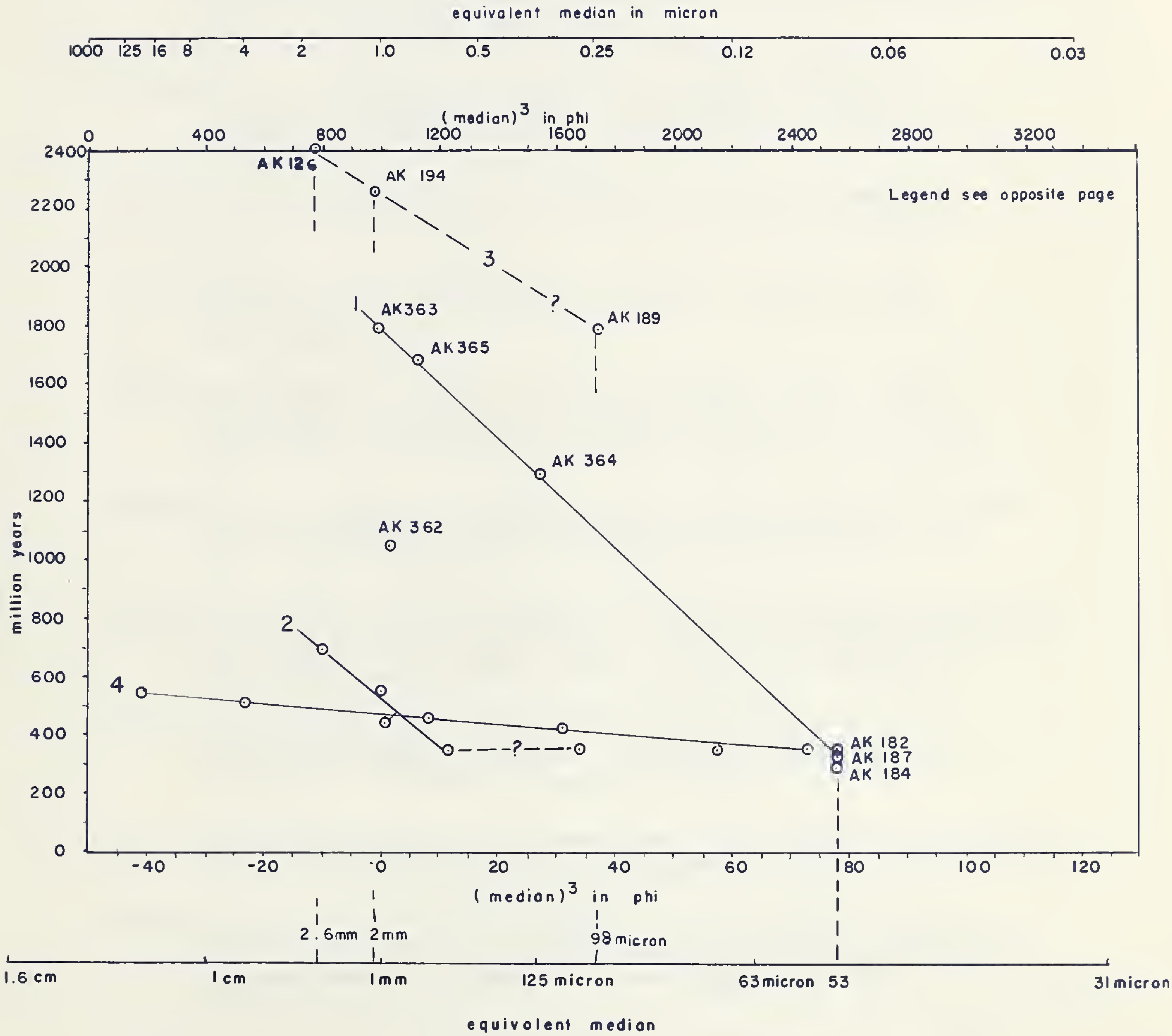
Function 3 ...... Burwash and Baadsgaard, Canadian Shield - Lower horizontal scale

Function 4 ...... Hower, Sylvan Shale - Upper horizontal scale

AK 362 .... Steiner, Jasper Formation - Lower horizontal scale

FIG. 17

K-A Age and Metamorphism
Detrital Muscovite and Illite



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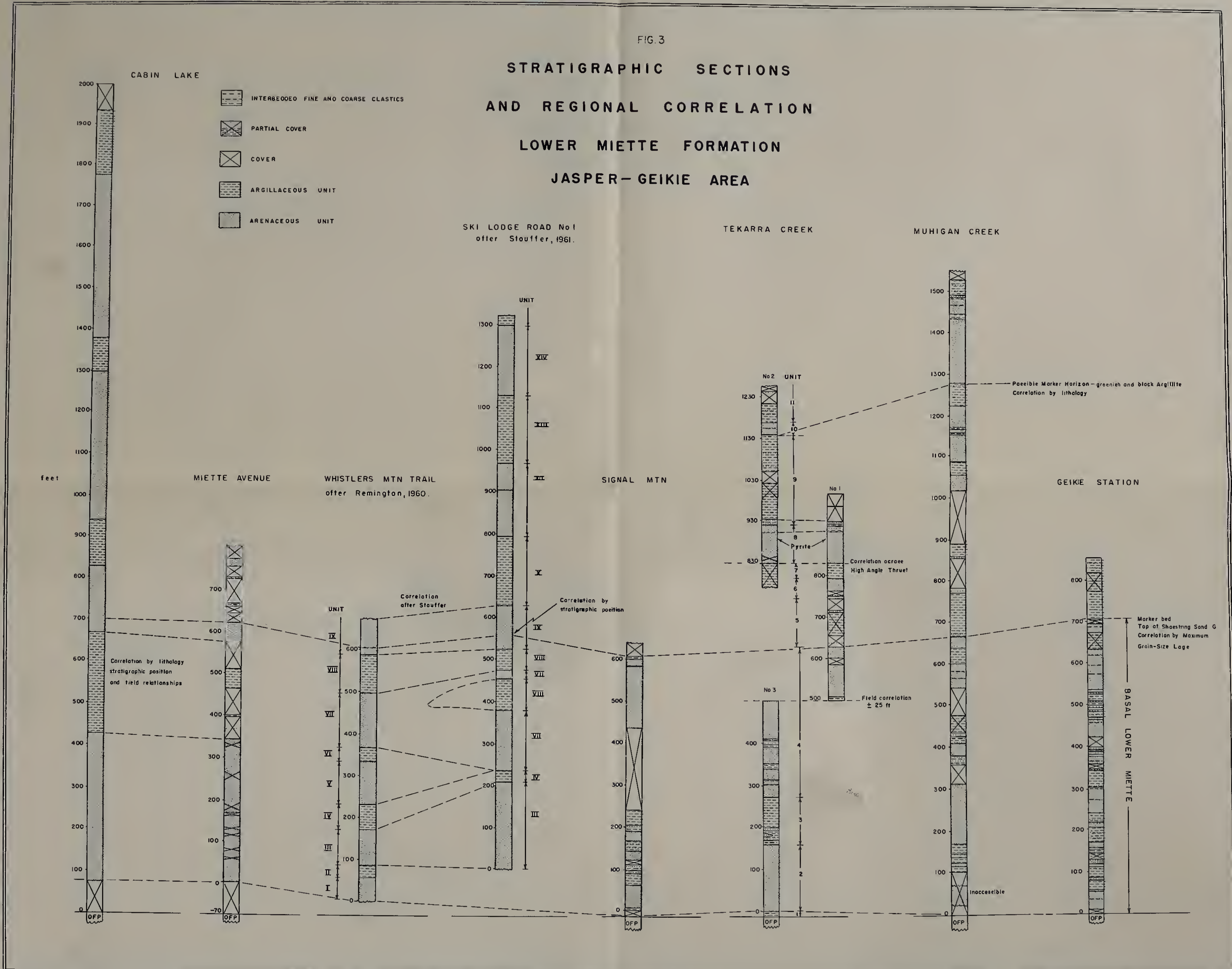

FIG. 3

STRATIGRAPHIC SECTIONS AND REGIONAL CORRELATION LOWER MIETTE FORMATION JASPER—GEIKIE AREA

FIG. 4

LOWER MIETTE FORMATION – MAXIMUM GRAIN-SIZE LOGS

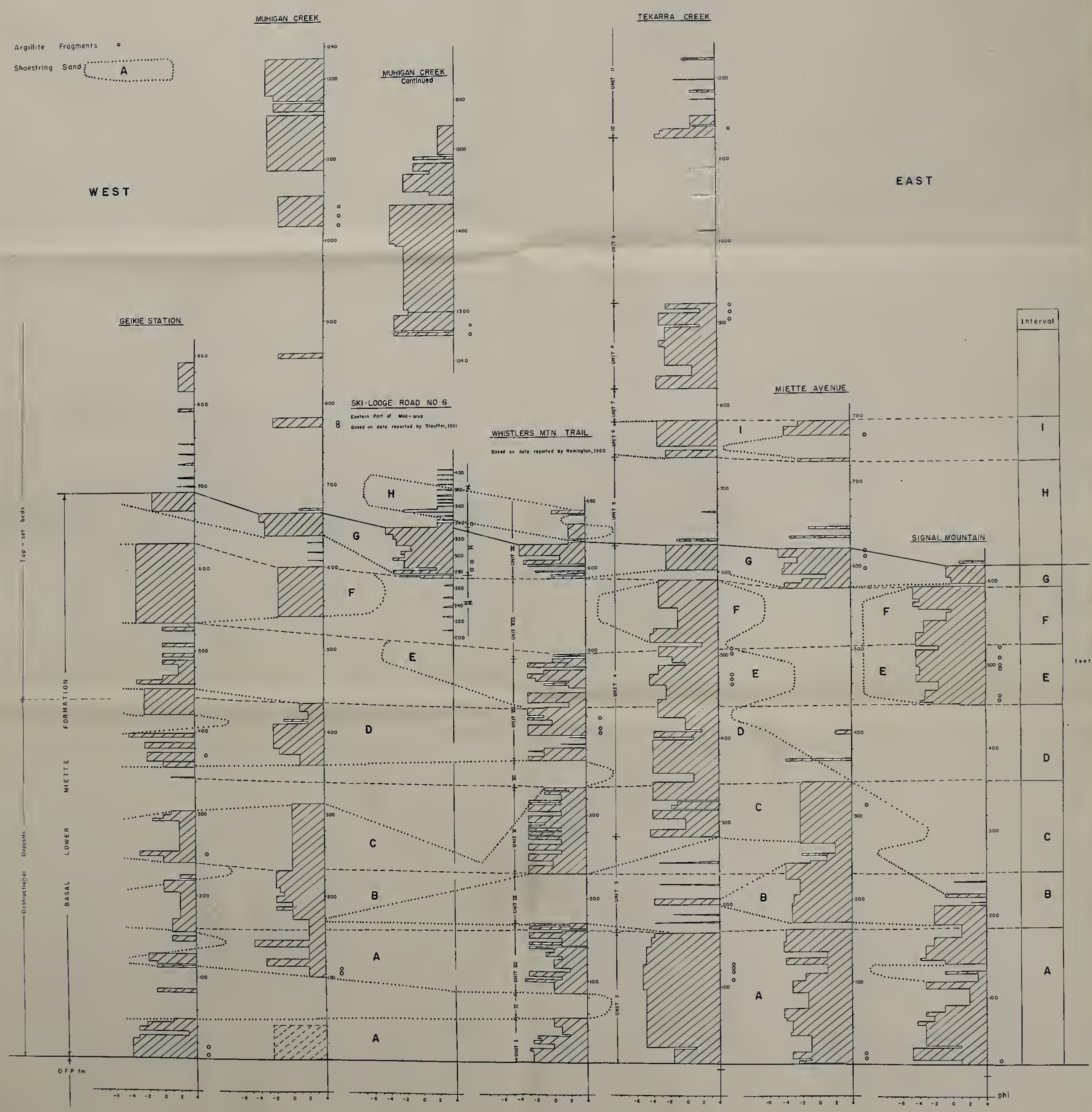

FIG. 15

Fracture Analysis

CONTOUR DIAGRAMS OF POLES TO JOINT PLANES

FIGURES 1 TO 8 PRESENT ORIENTATION

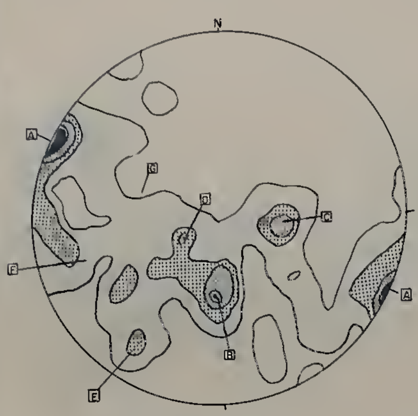

Fig 1: All Joints and veins
Tekarra Creek

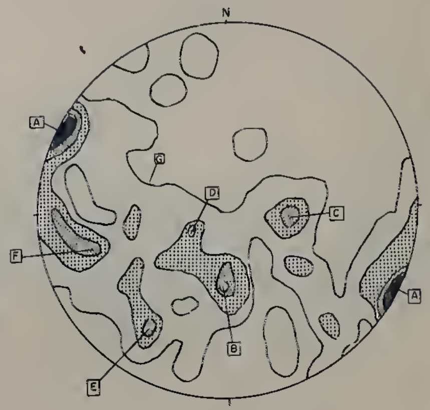

Fig 2: All Joints and veins
All Sections

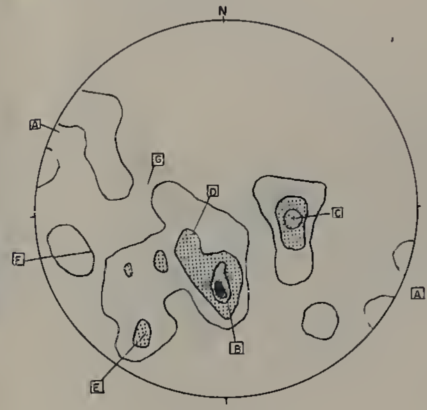

Fig 3 Veins
Tekarra Creek

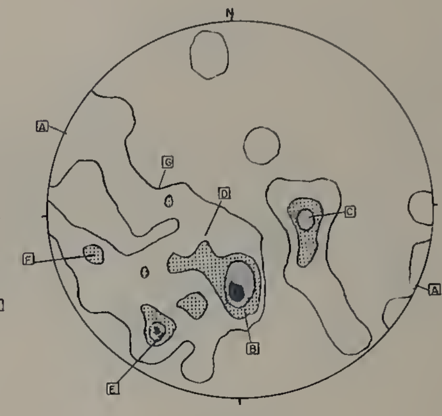

Fig 4 Veins
All Sections

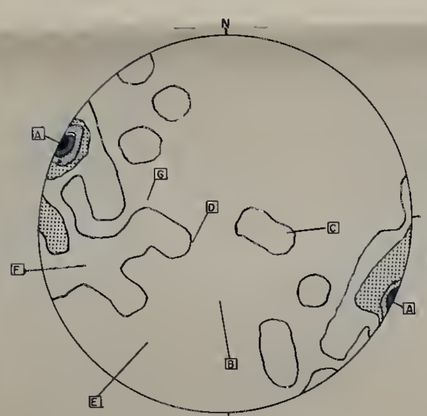

Fig 5: Unmineralized Joints
All Sections

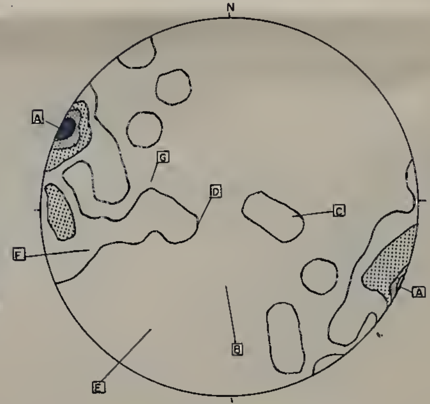

Fig 6 Unmineralized Joints
Tekarra Creek

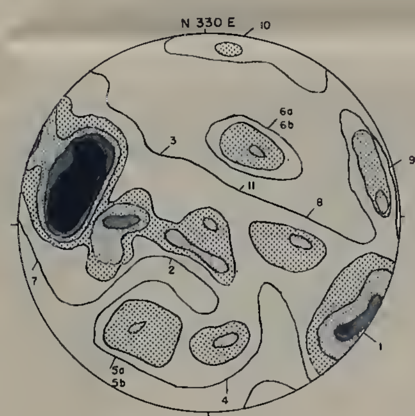

Fig 7: All Joints – Miette fm
Ski-Lodge Road after
Stouffer

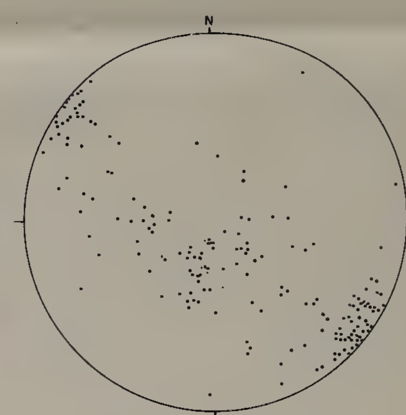

Fig 8: All Joints – Old Fort Point fm.
Jasper Anticlinorium after
Evans

FIGURES 9 TO 14 ORIENTATION AFTER ROTATION OF BEDDING INTO THE HORIZONTAL

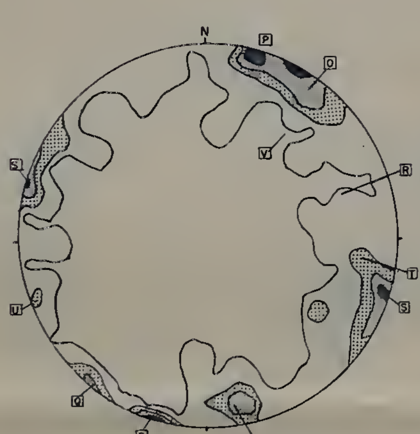

Fig 9 All Joints and veins
Tekarra Creek

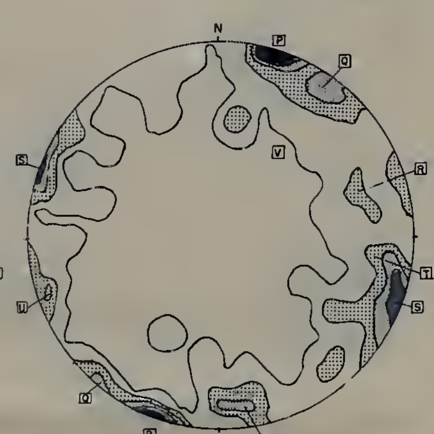

Fig 10: All Joints and veins
All Sections

Fig 11: Veins
Tekarra Creek

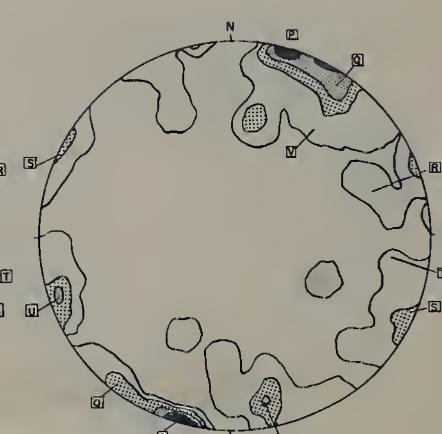

Fig 12: Veins
All Sections

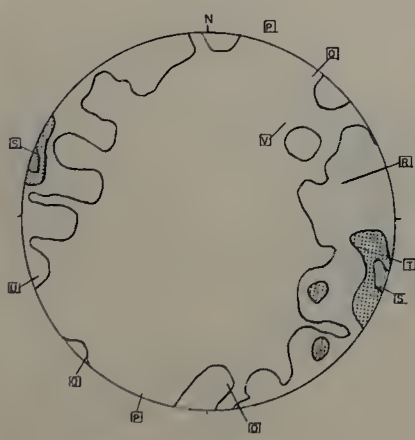

Fig 13 Unmineralized Joints
All Sections

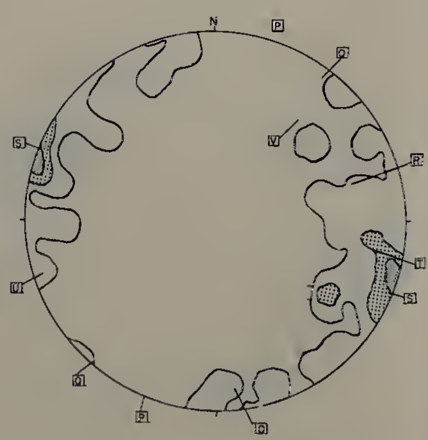

Fig 14 Unmineralized Joints
Tekarra Creek

Fig 15 Poles to Bedding Planes
Tekarra Creek

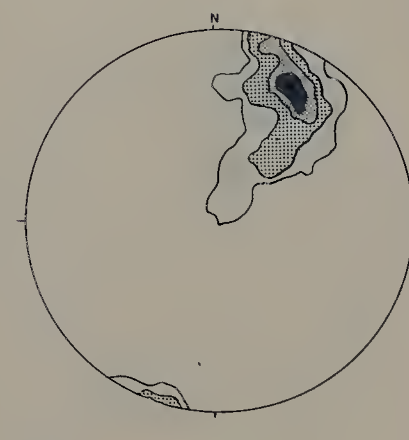

Fig 16. Poles to Bedding Planes
All Sections

Contour interval 1   Contour interval 2   Contour interval 3   Contour interval 4   5